FINAL REPORT

Volume I

Evaluation of the Effects of AFFF Inputs on the VIP Biological Nutrient Removal Process and Pass-Through Toxicity

PHASE 1A

Submitted to:

Naval Research Laboratory

Civil and Environmental Engineering Department
Old Dominion University
October 1997

Project No. N00014-96-1-G021

19971124 071

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-018

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
October, 1997

3. REPORT TYPE AND DATES COVERED
Phase IA Study, Sept. 1996 - Sept 1997

4. TITLE AND SUBTITLE
Evaluation of the Effects of AFFF Inputs to the VIP Biological Nutrient Removal Process and Pass-through Toxicity Vol. 1

5. FUNDING NUMBERS
Grant No: N00014-96-1-G021
PR-Number: 61-2330-96
Disburing Code: N68342
AGO Code: N66020
CAGE Code: 50075

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8. PERFORMING ORGANIZATION REPORT NUMBER
Project Number: 270351

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Naval Research Laboratory
4555 Overlook Avenue, SW
Washington DC 20375-5326

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for Public Release

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This report discusses the results of a bench scale study conducted to evaluate the potential inhibitory effects of untreated AFFF wastewater to the Virginia Initiative Plant (VIP) biological nutrient removal process. A bench-scale study was conducted to evaluate the potential inhibitory effects of untreated AFFF wastewater to the nitrification process of the Virginia Initiative Plant biological nutrient removal system. Under this testing, bench-scale reactors simulating the nitrification process were loaded at various AFFF concentrations and the influence on the process performance was evaluated. The purpose of this effort was to determine the level of AFFF that could be incorporated into the influent of a biological nutrient removal process without causing inhibitory effects. The results of the nitrification inhibition study showed that the AFFF concentrations tested in the range between 10 ppm to 60 ppm did not show any significant inhibition to biological nitrification. The effluent from each reactor did not exhibit any pass-through toxicity as well.

14. SUBJECT TERMS

15. NUMBER OF PAGES
185

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

TABLE OF CONTENTS

LIST OF TABLES .... Following Page Number

LIST OF FIGURES **Following Page Number**

EXECUTIVE SUMMARY

The US Navy utilizes a surfactant in fire fighting water that improves the ability to control petroleum-based fires. This surfactant is currently manufactured by up to five companies and is commonly referred to as AFFF (aqueous film-forming foam) conforming to military specifications Mil-F-24385F. Present concerns over inhibitory effects of AFFF wastewater have resulted in the prohibition of its disposal to the Hampton Roads Sanitation District (HRSD) collection system where it would eventually enter one of the biological wastewater treatment plants operated by the District. HRSD is particularly concerned with how AFFF wastewater might interfere with biological nutrient removal processes (BNR) at its Virginia Initiative Plant (VIP). The Navy does not discharge to that plant but HRSD wants to check the impact on the VIP process because it is more sensitive than a conventional activated sludge processes used by other HRSD Plants in which the Navy discharges to and HRSD plans to upgrade all of their plants to the VIP process eventually.

HRSD has indicated that compatibility of AFFF wastewater with the BNR process must be demonstrated prior to granting the necessary permit to discharge AFFF wastewater to the wastewater collection system leading to their plants. Previous studies were performed using surrogate AFFF compounds (AFFF-S), however, they did not address actual AFFF discharges. The overall objective of this study was to study the impact of AFFF wastewater to a biological nutrient removal process and determine whether pass-through toxicity occurs in the effluent of a biological process receiving wastewater containing AFFF.

A bench-scale study was conducted to evaluate the potential inhibitory effects of untreated AFFF wastewater to the nitrification process of the VIP BNR. In order to maintain a continuous supply of uniform nitrifying microorganisms to the bench-scale reactors, a fill-and-draw type batch reference reactor was operated continuously at the Civil and Environmental Engineering laboratory at Old Dominion University. The reactor was operated sequentially in aerobic feed, anaerobic, aerobic, settle and decant phases. Feed aeration, mixing, and decant were all controlled by a programmable controller. After a specified settling period, supernatant (effluent) from the reactor was withdrawn by a solenoid valve and collected in a sample bottle for analysis regularly.

Nitrification inhibition was assessed in series for untreated AFFF wastewater using a batch assay procedure. Inhibition tests were performed with different concentrations of AFFF and controls using six, 6-liter batch reactors. The inhibition reactors were operated following the same sequential cycle of the reference reactor. The degree of ammonia oxidation in reactors receiving a loading of AFFF wastewater was compared to the degree of oxidation in control reactors receiving similar volumes of tap water. Toxicity pass-through testing was also performed to determine maximum loadings of the untreated AFFF wastewater that would not cause toxicity in the effluent from a BNR process. Acute toxicity of the effluent to *Mysidopsis bahia* (mysid shrimp) and *Cyprinodon variegatus* (sheepshead minnow) have been examined in toxicity testing of both control and AFFF-loaded inhibition reactors.

The results of the nitrification inhibition study showed that the AFFF concentrations tested in the range between 10 ppm to 60 ppm did not show any significant inhibition to biological nitrification. The intensity of foaming in the reactors increased with the increasing AFFF concentrations and the loss of solids from the reactors was associated with the foaming density. At AFFF concentrations between 10 ppm to 50 ppm, the loss of solids increased. However, at 60 ppm, the foaming was so much denser that it did not allow solids carryover from the reactors. Uninhibited nitrification was also observed among the reactors that had excessive foaming. There was significant COD removal observed for each AFFF concentration tested as well. However, the percent COD removal in the inhibition reactors was less than that of the control reactors. While the percent COD removal decreased with increasing AFFF concentration, the amount of COD removed actually increased (on a mg/L basis). This observation is a direct result of the addition of COD associated with the AFFF. The acute toxicity test results showed that the effluent from each inhibition reactor did not exhibit any pass-through toxicity.

Fluoride measurements were also conducted for controls and the AFFF wastewater during the inhibition testing to examine fluoride release. A linear relationship was observed up to 50 ppm AFFF which signified that organo-fluoride compounds were being decomposed in proportion to the AFFF concentration. The low release of fluoride for the 60 ppm AFFF wastewater suggested some interference in fluoride release due to the inhibition of the microorganisms that were capable of decomposing these compounds or evidence of selective substrate utilization

where microorganism were consuming other preferable compounds before selecting organo-fluoride compounds.

Overall, the results of Phase 1A study indicated that AFFF solutions discharged into the wastewater at concentrations 60 ppm or below did not exhibit any inhibitory effect to biological nitrification and pass through toxicity.

1.0 INTRODUCTION

1.1 Overview

The US Navy utilizes a surfactant in fire fighting water that improves the ability to control petroleum-based fires. The surfactant, which is widely used by the Navy including facilities in the Hampton Roads region, is currently manufactured by up to five companies and is commonly referred to as AFFF (aqueous film-forming foam) conforming to military specifications Mil-F-24385F. The AFFF chemical makeup is not well known and likely varies among manufacturers and between batches. The US Navy is exploring a number of options that include disposal of the fire fighting water to wastewater collections systems where the components of AFFF wastewater would be removed biologically.

Current disposal of fire fighting water that includes AFFF wastewater has been limited by concerns for the environmental/toxic effects associated with AFFF. Disposal of the fire fighting foam to sanitary sewers has been considered as an option, however, concern for the potential toxic or inhibitory effects associated with AFFF wastewater have generally led to a ban from introduction of AFFF to wastewater collection systems.

Several studies have been performed on the disposal and treatment of AFFF surrogate (AFFF-S) wastewater using surfactants such as CalsoftL-40 (Pilot Chemical Co.), DRFS (Dominion Restoration Inc.), Micro Blazeout (Verde Environmental), and Silv-Ex (Ansul Fire Protection). Bench-scale anaerobic and aerobic reactors were used to investigate the potential inhibition of the AFFF surrogates to nitrification, denitrification, and phosphorus release and uptake in a biological nutrient removal (BNR) process [1,2]. These effects were investigated for both untreated and pretreated AFFF-S wastewater. The results showed that pretreating a wastewater containing AFFF-S allowed for complete nitrification and denitrification and untreated or pretreated wastewater did not have any adverse effect on denitrification and phosphorus release. The use of coagulants such as alum, ferric chloride, calcium chloride, and cationic polymers also have been observed to be capable of reducing the organic content of AFFF [1,2,3,4].

Treatability studies have also been conducted with a high-purity oxygen activated sludge system. The results showed that acceptable levels of biological treatment could be obtained with untreated firefighting wastewater diluted by a factor of 100. The use of dissolved air flotation treatment on the firefighting wastewater further reduced the dilution ratio needed for acceptable effluent quality from the biological process [5,6].

The use of chemical pretreatment with dissolved air flotation (DAF) provided consistent removal of chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solids (TSS), and firefighting surfactants [7]. Overall, the use of coagulation, flocculation, and clarification aided in the reduction of organics prior to discharge to a BNR process. Upon chemical pretreatment and using aerobic and anaerobic sequencing batch reactors, it was found that an acceptable effluent that is amenable to an aquatic stream could be processed [8, 9, 10]. Additional studies were performed to determine the biodegradability of AFFF wastewater. Some of the additional work included the use of wastewater containing actual fire fighting water and AFFF. However, detailed testing on the effects of actual AFFF wastewater on biological nutrient removal was not performed in these studies [11, 12]. The biodegradability of commonly used AFFF surrogates which have been used in training activities were evaluated on bench-scale, continuous-feed activated sludge processes [13, 14, 15]. The AFFF dose that was fed to the reactor increased gradually from 100 ppm to 250 ppm. The results exhibited very good BOD and COD removal rates, however, nitrification was inhibited with increasing AFFF concentrations.

Present concerns over inhibitory effects of AFFF wastewater have resulted in the prohibition of its disposal to the Hampton Roads Sanitation District (HRSD) collection system where it would eventually enter one of the biological wastewater treatment plants operated by the District. HRSD is particularly concerned with how AFFF wastewater might interfere with biological nutrient removal processes at its Virginia Initiative Plant (VIP). The Navy does not discharge to that plant but HRSD wants to check the impact on the VIP process because it is more sensitive than a conventional activated sludge processes used by the Army Base, Atlantic, and Chez-Eliz Plants in which the Navy discharges to and HRSD plans to upgrade all of their plants to the VIP process eventually. The VIP plant incorporates biological nitrogen,

phosphorous, and organic matter (BOD/COD) removal through a sequential series of anaerobic, anoxic, and oxic reactors. Nitrogen removal occurs through microbially-mediated nitrification and denitrification and phosphorous removal occurs through enhanced uptake by poly P bacteria. It is well known that the nitrification and denitrification processes can be inhibited in the presence of various chemicals and Poly P bacteria have been observed to be inhibited by H_2S and 2,4-dinitrophenol. Because of the sensitivity of these microbial processes to inhibition, it is important to characterize the relationship between concentrations of various chemicals and the rates of conversion of nitrogen, phosphorous, and organic substrate.

HRSD has indicated that compatibility of AFFF wastewater with the BNR process must be demonstrated prior to granting the necessary permit to discharge AFFF wastewater to the wastewater collection system leading to their plants. Toxicity pass-through potential of AFFF is also another concern to HRSD. The US Navy at Naval base Norfolk previously supported two studies [1,2] to investigate the impact of AFFF on the BNR process in support of their request to dispose of AFFF to the wastewater collection system. The study methodologies in these two studies, including the use of a reference reactor and inhibition testing with sequencing batch reactors operating on cycles of aerobic feed, anaerobic react, and settling were approved by HRSD. However, instead of using AFFF that is utilized by the Navy, surrogate AFFF compounds (AFFF-S) were used. The two studies by CH2M Hill were performed using AFFF-S for the sole purpose of identifying the need for pretreatment and/or obtaining authority to construct and discharge AFFF-S wastewater to HRSD from the new fire training school at FTC Norfolk. Neither study was intended to address AFFF discharges. The current study is required to determine the level at which AFFF causes process inhibition or pass through toxicity so that discharge permits can be modified to allow the non-routine discharge of AFFF from sources other than the fire training school at FTC Norfolk (i.e., hangar fire protection systems and fire truck testing). The results were not accepted by HRSD since the AFFF solution used by the Navy was not tested. This situation lead to the current study which involved directly evaluating the impact of AFFF (as used by the Navy) on a BNR process.

A bench-scale study was conducted to evaluate the potential inhibitory effects of untreated AFFF wastewater to the nitrification process of the VIP BNR. Under this testing, bench-scale

reactors simulating the nitrification process were loaded at various AFFF concentrations and the influence on the process performance was evaluated. The purpose of this effort was to determine the level of AFFF that could be incorporated into the influent of a biological nutrient removal process without causing inhibitory effects. Toxicity pass-through testing was also performed to determine maximum loadings of the untreated AFFF wastewater that would not cause toxicity in the effluent from a BNR process.

This study was performed in two phases which will be referred to as Phase IA and Phase IB. This report contains the results of Phase 1A in which the primary intent was to determine the potential inhibitory effect of untreated AFFF solution on the biological nutrient removal process. It also was investigated whether toxicity passes through to the effluent in the biological treatment process. Phase IB (not addressed in this report) will include evaluating inhibitory effects of AFFF solution after pretreated at five operational conditions as well as whether toxicity passes to the effluent.

1.2 Study Objectives

The overall objective of this study was to study the impact of AFFF wastewater to a biological nutrient removal process and determine whether pass-through toxicity occurs in the effluent of a biological process receiving wastewater containing AFFF. Specific objectives of this study include:

- Determine the relationship between AFFF concentrations (i.e. % full strength, flouro-organic compounds, butyl carbitol concentration) in influent wastewater and the degree of inhibition of nitrogen, phosphorous, and COD removal under a variety of operating conditions similar to those of the VIP plant;

- Identify conversion/removal through biological treatment of specific components of the AFFF surfactant (see analytical methods below);

- Measure the acute toxicity of the treatment reactors' effluent to *Mysidopsis bahia* (mysid shrimp) and *Cyprinodon variegatus* (sheepshead minnow) to assess the possibility of toxicity pass through in a process similar to the VIP process;

- Determine the chemical/parameter specific concentrations of the AFFF wastewater effluent quality with respect to parameters specified in HRSD industrial pretreatment guidelines. Also document appropriate findings from a treatment and aesthetic standpoint.

2.0 METHODS AND MATERIALS

2.1 Reference Reactor Operation

In order to maintain a continuous supply of uniform nitrifying microorganisms, a fill-and-draw type batch reference reactor was used at the Civil and Environmental Engineering laboratory at Old Dominion University. The reference reactor consisted of a 30-gallon polyethylene tank containing a hexagonal-shaped poly vinyl chloride (PVC) air diffuser and a rapid mixer. It was initially seeded with mixed liquor suspended solids (MLSS) collected from the secondary clarifiers at the VIP plant. The solids were allowed to settle and the supernatant was decanted. The reactor was then fed over the duration of the study with a synthetic feed solution comprised of organic and inorganic compounds necessary to support a healthy population of nitrifying, denitrifying and phosphorus removing bacteria. This feed was the same composition used in a previous study of AFFF-S[2]. Table 2-1 shows the organic and inorganic constituents used for preparing the feed solution. Some changes to the feed composition were made during the study and these changes are mentioned in subsequent sections. The reactor was fed this solution throughout the feed stage with a peristaltic pump. The reactor was operated sequentially in aerobic feed, anaerobic, aerobic, and settle and decant phases. Feed aeration, mixing, and decant were all controlled by a programmable controller.

Air supply was adjusted to maintain 4 mg/l of dissolved oxygen (DO) in the reactor during the feed and aeration stages. A submersible DO probe with a DO meter was continuously used to monitor the DO concentration in the reactor. The feed tank consisted of a 30 gallon polyethylene tank which was placed in a refrigerator at 4^0C. The feed tank was refrigerated to limit bacterial growth in the feed tank. The reactor was operated in a cyclical mode for a period of sixteen hours for each cycle. Operation of each cycle comprised of 4-hour feed with aeration, 4-hour anaerobic, 4-hour aerobic, 4-hour settle and a two-minute decant period. During each cycle, 7.5 gallons of feed was supplied and the same amount was decanted as supernatant. The total volume in the reactor was 24 gallons. The feed and supernatant were collected and analyzed for COD and ammonia nitrogen (NH_3-N) twice per week. The reactor was also monitored for MLSS and sludge volume index (SVI) twice per week. The COD analyses was favored over BOD as it gave

Table 2-1: Organic and inorganic synthetic wastewater constituents

Organic Feed Stock				
Constituent	Ref.Conc. g/L*	Conc/CH2M mg/L*	Grams for 30 gal soln	Grams per Gal.
Beef Extract	9.0730	56.9784	16.1748	**0.5392**
Bactopeptone	13.1960	82.8709	23.5250	**0.7842**
Urea	2.4740	15.5367	4.4105	**0.1470**
KH_2PO_4	4.7420	29.7798	8.4537	**0.2818**
K_2HPO_4	1.8560	11.6557	3.3088	**0.1103**
$(NH_4)_2CO_3$	9.3610	58.7871	16.6882	**0.5563**
$NaHCO_3$	13.7330	86.2432	24.4823	**0.8161**
Na_2CO_3	38.4760	241.6293	68.5925	**2.2864**
CH_3COOH	9.5710	60.1059	17.0626	**0.5688**

Inorganic Feed Stock				
Constituent	Ref.Con g/L*	Conc/CH2M mg/L*	Grams for 30 gal soln	Grams per Gal.
$MgSO_4$	18.804	23.693	6.7259	**0.2242**
$CaCl_2.2H_2O$	4.9500	6.2370	1.7705	**0.0590**
NaCl	82.50	103.95	29.5088	**0.9836**
$FeSO_4$	2.0630	2.5994	0.7379	**0.0246**
$MnSO_4.H_2O$	0.0186	0.0234	0.0066	**0.0002**
$CuSO_4$	0.0012	0.0015	0.0004	**0.0000**
$Na_2MoO_4.2H_2O$	0.0007	0.0008	0.0002	**0.0000**
$ZnSO_4.7H_2O$	0.0193	0.0243	0.0069	**0.0002**

* - Concentrations obtained from a previous study, done by CH2M HILL.

very fast and repeatable results. However the BOD:COD ratio was periodically checked for both the feed and the supernatant in order to evaluate the stability of the ratio.

2.2 Analytical Methods

The analytical methods employed in this study for evaluating the effects of AFFF wastewater inputs on biological treatment performance consisted of procedures as prescribed by the United States Environmental Protection Agency (USEPA) [16] or in Standard Methods [17]. All chemicals used were reagent grade or better and all quality assurance/quality control procedures were followed as closely as possible.

Measurements of organic strength were determined through carbonaceous five day BOD ($CBOD_5$), COD, and total organic carbon (TOC) measurements. $CBOD_5$ (determined with a nitrification inhibitor added to BOD bottles) were measured to eliminate potential interferences that nitrification could have on the evaluation of organics removal with the BOD test. CBOD, COD, and TOC analyses were determined using filtered samples on reactor effluent and filtered and unfiltered samples in the influent. Samples were filtered through a glass fiber filter to eliminate microorganisms and other particulate materials that are not related to the organic components of the AFFF or the dissolved organic compounds that are in the wastewater before AFFF introduction. Since the AFFF components are water soluble and will be dissolved in solution, filtration should not directly interfere with their accurate detection. Measurements of total suspended and volatile suspended solids (TSS and VSS, respectively) were used to determine organic solids loading, reactor MLSS concentrations, and non-settleable TSS concentrations in reactor effluent. In order to reduce variability of TSS and VSS data, the tests were performed on the same days that solids concentrations feeding into the reactor. The nitrogen series were determined by three different analytical techniques. Persulfate digestion followed by ammonia analysis by ion selective electrode was utilized to determine total Kjeldahl nitrogen (TKN) concentrations, ammonia concentrations were measured by ion selective electrode without sample digestion, and nitrate and nitrite concentrations were determined on filtered samples using ion chromatography. Orthophosphate was similarly determined using ion chromatography.

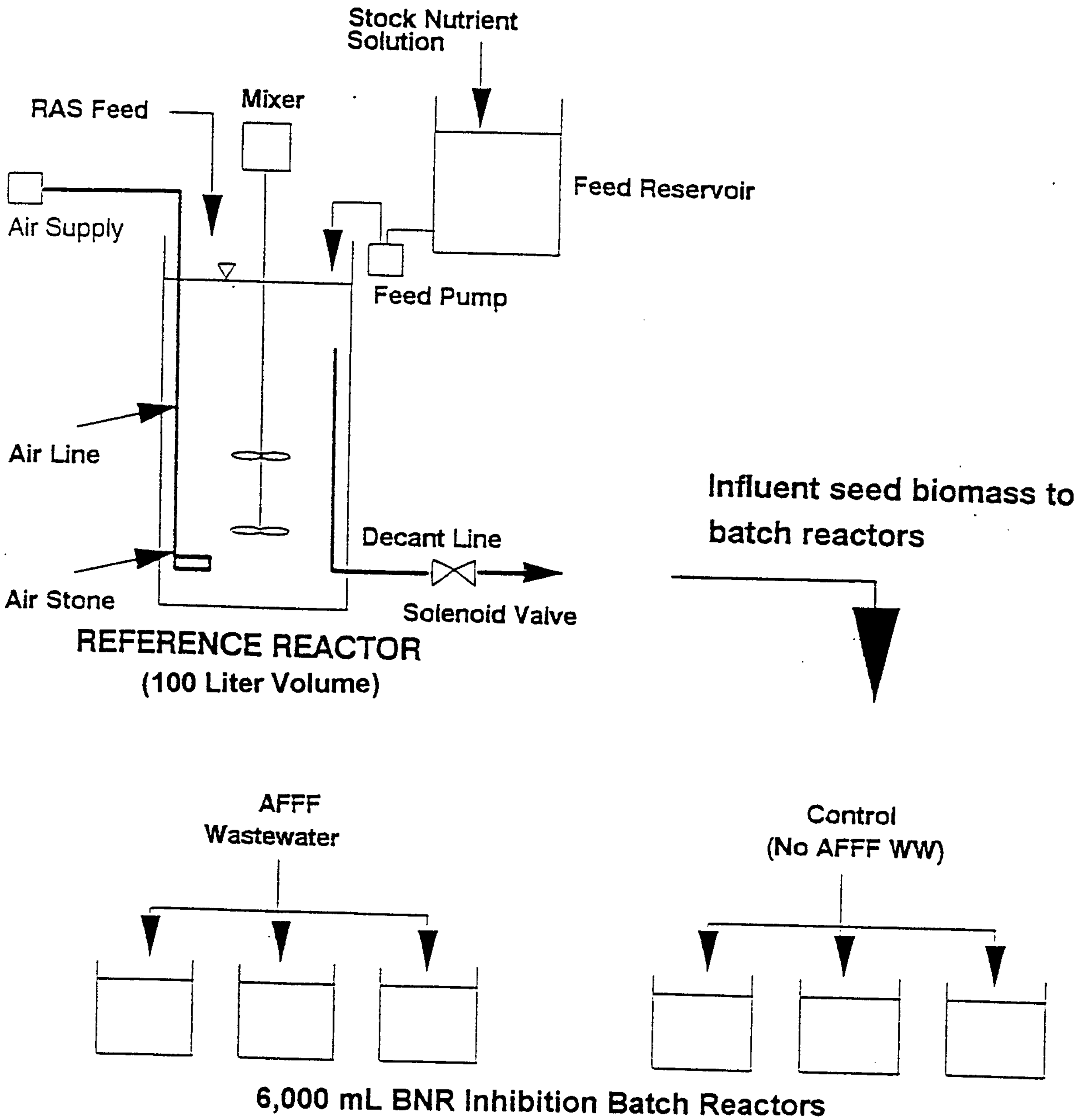
As part of this study, butyl carbitol, a major component of AFFF, is also being analyzed by ion chromatography utilizing electrochemical detection. Decomposition of fluoro-organic compounds are being evaluated by ion chromatography through determination of inorganic fluoride directly and inorganic fluoride following persulfate digestion. The change in fluoride concentration between pre- and post- digestion will give an indication of the amount of fluoride that is tied up in organic compounds. In addition to this indirect determination, the investigators are working with Dionex Corporation to develop a method that will directly measure fluoro-organic compounds. If method development is successful, this procedure will also be used to characterize the influence of treatment on the conversion of these compounds. These results will be provided in the Phase 1B report.

2.3 BNR Inhibition Batch Assays

Nitrification inhibition was assessed in a series of batch experiments with AFFF-laden wastewater. Inhibition tests were performed using six, 6-liter batch reactors of which three were controls (no AFFF added) and three were a single desired concentration of AFFF as shown in Figure 2-1. Uniform seed biomass of approximately 4,000 mg/L was obtained from the reference reactor for each batch reactor. Approximately 2,000 mL of the appropriate organic and inorganic nutrients were added from the stock nutrient tank and stock (undiluted) AFFF was added in sufficient volume to the nutrient broth to obtain the test AFFF concentration needed. Each batch reactor was equipped with an air supply source, an air stone, and a mixer. After the uniform seed biomass was added to each reactor, the air was turned on and the feed stock solution was introduced manually at 0, 30, 60, and 90 minutes during the two hour fill cycle. The reactors were mixed and aerated during the feed cycle and dissolved oxygen was monitored to insure adequate aeration. At the end of this cycle, samples were withdrawn and the reactors were covered with lids to achieve anaerobic conditions. Mixing was continued throughout this cycle to maintain the biomass in suspension.

At the end of the two hour anaerobic cycle another sample was withdrawn from each reactor, air was turned on and the lids were removed. Aeration and mixing were continued for another two hours, and additional samples were taken at the end of the aerobic cycle. Finally, the reactor

Figure 2-1: BNR Inhibiton Batch Assays



contents were allowed to settle for two hours and samples taken from the supernatant were removed during the decant cycle. Each sample from the reactors was analyzed for pH, TKN, ammonia, NO_3^-, NO_2^-, orthophosphate, COD, BOD, TSS, VSS, TDS, and alkalinity. Comparisons were made between the controls which did not contain any AFFF and the reactors dosed with AFFF.

The degree of ammonia oxidation in beakers receiving a loading of AFFF wastewater was compared to the degree of oxidation in control reactors that did not contain any AFFF. All samples were held for less than 48 hours prior to analytical testing. While performing the inhibition batch assay experiments, dissolved oxygen concentrations were determined during the feed and aeration cycles. This was done by measuring the dissolved oxygen depletion of a mixed liquor sample taken from each reactor into a BOD bottle for a period of five minutes. Oxygen uptake rates were measured and the respiration rates were determined by specific oxygen uptake rate (SOUR = OUR/MLVSS) measurements. This procedure provided an indication of the effects of the untreated AFFF wastewater on the microorganisms.

2.4 Toxicity Pass-Through Testing

Toxicity pass-through testing was performed on the inhibition reactors (controls and AFFF-dosed) to estimate what the maximum concentration of AFFF to the BNR process would be without causing effluent toxicity. The acute toxicity pass-through tests were performed using the procedures outlined by the USEPA [18]. At the end of the BNR inhibition batch aeration period, the mixed liquor was allowed to settle and clarified supernatant was decanted from each reactor and filtered through a coarse glass fiber filter. This filter is of the same type that is used for suspended solids analysis with 10 micrometer nominal size and without organic binder. Prior to use, the glass fiber filters were rinsed thoroughly by passing high-purity, deionized distilled water through the filter. The filtration apparatus was rinsed between each sample aliquot using 10 percent HNO_3, acetone and high purity water. The filter toxicity was also checked by testing filtered dilution water.

Toxicity samples were submitted to a qualified bioassay laboratory for acute toxicity testing using *M. bahia* and *C. variegatus* following the current EPA procedures. It was ensured

that the laboratory would perform a standard reference toxicant test on a regular basis and develop accompanying quality control charts. All samples were held for less than 48 hours prior to use in testing.

3.0 RESULTS

The Phase 1A results of this study include AFFF waste characterization, initial range finding tests, inhibition tests, and toxicity pass-through. Each result will be described in the following sections. Detailed results along with the raw data are attached in Appendices I through V of this report.

3.1 AFFF Waste Characterization

The AFFF compound used in this study is manufactured by the 3M Company. The name of the compound is FC-203CE Lightwater™ brand Aqueous Film Forming Foam. Before analyzing for the priority pollutants, the manufacturer of the AFFF was contacted and a letter from the Company was obtained specifying the levels of different compounds that may be present in the AFFF.

Most of the priority pollutants were either claimed not to be intentionally added, or known to be present according to 3M Company. A copy of the Material Safety Data Sheet (MSDS) was also obtained along with technical information bulletin specific to AFFF. Copies of the certified letter from 3M Company, recently updated MSDS, and technical information bulletin are attached in Appendix I of this report.

Among the chemical specific measurements required by HRSD, BOD_5 is reported as 0.091 g/g, and COD is reported as 0.740g/g in the MSDS data. The pH value was measured as 8.0 at 77°F. The TSS, TKN, TOC and alkalinity measurements were not specification requirements for AFFF, therefore, they were measured in the Environmental Engineering laboratory of ODU along with the fluoride concentration.

Of the pesticides and PCBs, the compound Tolyl triazole (CAS# 29385-43-1) is stated to be present at 0.05 percent as shown in the MSDS. Butyl carbitol,(CAS# 112-34-5) is also present as diethylene glycol butyl ether at 30 percent by volume. The surfactant component of AFFF is a trade secret and was not disclosed by the 3M Company. Table 3-1 shows a summary of the chemical/parameter specific measurements determined in the laboratory for some parameters and specified by the 3M Company for most of the remaining parameters.

Table 3-1
Chemical/Parameter-Specific Measurements

Parameter	Concentration
BOD_5	0.091 g/g
COD	0.740 g/g
TSS, EPA 160.2	<5 mg/L
Cl_2 residual	Not intentionally added or known to be present by the manufacturer
pH, conventional	8.0 at 77°C
Total Phosphorus	Not intentionally added or known to be present by the manufacturer
TKN, EPA 351.2-1 thru -5	<0.5 mg/L
Chlorides, Standard Methods 4500.B	1 mg/L
TOC, Standard Methods	156,000 mg/L
NH_3,	Not intentionally added or known to be present by the manufacturer
Alkalinity, standard Methods 2320.B	520 mg/l as $CaCO_3$
TDS	Not intentionally added or known to be present by the manufacturer
Metals	Not intentionally added or known to be present by the manufacturer
Cyanide, by distillation	Not intentionally added or known to be present by the manufacturer
Pesticides and PCB's	Tolyl Triazole, 0.05% by volume
Volatile Organics	Butyl Carbitol, 30% by volume
Semi-volatile Organics	Not intentionally added or known to be present by the manufacturer
Acrolein	Not intentionally added or known to be present by the manufacturer
Acrylonitrile	Not intentionally added or known to be present by the manufacturer

1,2-Diphenylhydrazine	Not intentionally added or known to be present by the manufacturer
Arochlor 1252	Not intentionally added or known to be present by the manufacturer
Arochlor 1262	Not intentionally added or known to be present by the manufacturer
2,3,7,8-Tetrachlorodibenzo-p-dioxin	Not intentionally added or known to be present by the manufacturer
Methyl ethyl ketone	Not intentionally added or known to be present by the manufacturer
Methyl isobutyl ketone	Not intentionally added or known to be present by the manufacturer
Xylenes	Not intentionally added or known to be present by the manufacturer
Acetone	Not intentionally added or known to be present by the manufacturer
Surfactant	Trade secret (not disclosed)
Fluorohydrocarbons	Not intentionally added or known to be present by the manufacturer
Fluoride	May be present
Butyl Carbitol	30% by volume; method for direct measurement still under development

3.2 Reference Reactor Performance

The reference reactor was operated for 16 weeks and monitored for MLSS, MLVSS, SVI, COD, ammonia nitrogen, and TKN on a semi-weekly basis (Table 3-2). Collection of influent and effluent (supernatant) samples and the mixed-liquor allowed calculation of COD and ammonia removal as well as the food-to-microorganisms (F/M) ratio.

The average COD removal was approximately 95% while removal for ammonia-nitrogen averaged 90%. Throughout most of Phase 1A, the reference reactor exhibited good nitrification with > 98% ammonia removal. However, a sharp increase in the feed ammonia concentration occurred in the 10^{th} and 11^{th} week carried over to the supernatant indicating that significant nitrification inhibition occurred. Inhibition may have been caused by the elevated ammonia concentrations as high ammonia concentrations can be toxic to the nitrifying bacteria and inhibit the nitrification process. To overcome this problem the feed organic strength was reduced. The SVI values of the reactor increased significantly after five weeks of continuous operation. One of the reasons for this was thought to be aeration during the feed cycle and low nutrient loading to the reactor. To correct this problem, an unsuccessful attempt was made by adding hydrogen peroxide at 60 mg/l.

The initial F/M ratios in the reference reactor were very low. However, by gradually increasing the COD of the feed solution, the F/M ratios were increased. The purpose of increasing the F/M ratio was to simulate the VIP process that operates under an F/M ratio of approximately 0.22. As noted earlier, the reactor did not exactly simulate the VIP process. Aeration of the reactor during the fill stage caused the reactor to cycle from aerobic to anoxic to aerobic before settling. In contrast, the VIP process consists of an anaerobic, anoxic, aerobic sequence of conditions. The operation of the reference reactor under these conditions did not allow for P removal. Phosphorus removal is best achieved by having anaerobic and/or anoxic conditions preceding the aerobic cycle allowing poly P bacteria to become established. To assess the phosphorus removal and nitrate production in the reactor, the supernatant was analyzed by ion chromatography periodically and the results are tabulated in Tables 3-3 a, b, and c. As can be seen from these results phosphorus removal did not occur. Nitrite was generally low and it was observed on one occasion (February 18) to accumulate during aerobic periods indicating not all of

Table 3-2. Weekly Performance of the Reference Reactor during the course of the study

Week	MLSS	MLVSS	COD mg/l		% COD	SVI	NH3-N mg/l		TKN mg/l		F/M	Organic Load
	mg/l	mg/l	Feed	Super.	removal		Feed	Super.	Feed	Super.		mg/l/day
1	4060	3451	376	26	93.0	~~	6.4	0.2	33.3	1.9	0.03	169.0
	3940	3349	476	5	98.9	~~	22.5	0.2	34.2	4.0	0.04	214.3
2	3824	3250	495	24	95.2	~~	26.2	0.1	53.2	1.0	0.05	222.6
	3736	3175	~~	~~	~~	145.0	23.2	0.2	55.4	2.8	~~	
3	3636	3090	452	26	94.2	156.0	25.2	0.2	46.0	0.1	0.04	203.6
	2600	2210	478	22	95.4	~~	36.6	0.1	101.6	1.8	0.06	214.9
4	2768	2352	468	10	97.8	~~	20.4	0.0	48.4	0.1	0.06	210.7
	2908	2471	~~	~~	~~	~~	32.0	0.0	59.3	0.2	~~	
5	3024	2570	442	5	98.9	212.0	27.1	0.1	222.8	1.6	0.05	198.8
	3240	2754	672	39	94.1	~~	37.8	0.3	202.8	2.7	0.07	302.5
6	3323	2824	672	32	95.3	265.0	~~	~~	~~	~~	0.07	302.4
	3436	2920	974	18	98.1	258.0	~~	~~	~~	~~	0.10	438.3
7	2412	2050	968	77	92.1	344.0	~~	~~	~~	~~	0.14	435.5
	2956	2512	1421	9	99.4	314.0	26.0	0.1	144.6	2.9	0.17	639.6
8	3200	2720	~~	~~	~~	296.0	22.1	0.1	73.3	4.1	~~	
	3600	3060	~~	~~	~~	>400	29.0	0.4	312.5	2.1	~~	
9	2964	2519	807	76	90.5	>400	~~	~~	~~	~~	0.10	363.2
	2924	2485	971	151	84.5	>400	~	~~	~~	~~	0.12	437.1
10	3280	2788	1416	~~	~~	>400	58.3	15.3	995.1	57.9	0.15	637.2
	3024	2570	2250	156	93.1	>400	92.2	14.9	977.6	87.0	0.26	1012.4
11	3000	2550	1188	82	93.1	300.0	117.6	41.0	1245.4	87.0	0.14	534.7
	2668	2267	1231	55	95.5	292.0	80.9	0.2	977.6	8.5	0.16	553.8
12	2740	2248	1251	58	95.4	302.0	28.3	0.3	~~	~~	0.17	563.0
	2900	2420	1338	95	92.9	279.0	~~	~~	~~	~~	0.17	601.9
13	3220	2676	~~	~~	~~	~~	10.6	0.2	323.7	8.8	~~	
	2456	1976	~~	~~	~~	325.0	~~	~~	~~	~~	~~	
14	2704	2408	1300	90	93.1	332.0	35.7	0.4	413.9	6.2	0.16	585.0
	2160	1916	1300	90	93.1	~~	~~	~~	~~	~~	0.20	585.0
15	2372	2092	1400	100	92.9	379.0	30.3	0.3	454.5	6.4	0.20	630.0
	1740	1604	1200	90	92.5	>400	~~	~~	~~	~~	0.22	540.0
Average	**2975**	**2454**	**989**	**59**	**94.2**		**37.5**	**3.6**	**338.7**	**14.3**	**0.14**	**445.1**
	Average VSS--82.4%				note: ~~ = Data not available							

Table 3-3a: Nitrite Nitrogen concentration variation during different stages

	Nitrite (NO_2^--N) mg/l			
Sample	1/16/97	1/23/97	2/7/97	2/18/97
Feedstock	0.0	0.0	0.0	0.7
Start-of-Feeding	0.0	0.0	1.4	2.7
Middle-of-Feeding	0.0	0.0	0.6	0.7
End-of-Feeding	1.1	0.0	1.6	3.1
Middle-of-Anaerobic	1.1	0.0	1.5	0.7
End-of-Anaerobic	1.0	0.0	0.0	0.7
Middle-of-Aerobic	0.0	0.0	0.0	2.9
End-of-Aerobic	0.0	0.0	~~	3.5
Middle-of-Settling	0.0	0.0	~~	3.2
Supernatent	0.0	0.0	0.0	3.2

Table 3-3b: Nitrate Nitrogen concentration variation during different stages

	Nitrate (NO_3^--N) mg/l			
Sample	1/16/97	1/23/97	2/7/97	2/18/97
Feedstock	0.9	0.9	0.8	0.7
Start-of-Feeding	46.6	49.4	54.3	94.6
Middle-of-Feeding	44.6	43.0	33.9	83.1
End-of-Feeding	48.1	43.2	57.2	82.8
Middle-of-Anaerobic	46.2	41.8	53.2	76.5
End-of-Anaerobic	43.8	40.2	53.6	75.8
Middle-of-Aerobic	45.9	48.3	56.2	86.5
End-of-Aerobic	47.9	49.7	~~	101.8
Middle-of-Settling	48.3	49.7	~~	101.5
Supernatent	47.4	49.9	57.7	101.5

Table 3-3c: Orthophosphate concentration variation during different stages

	PO_4^--P mg/l			
Sample	1/16/97	1/23/97	2/7/97	2/18/97
Feedstock	20.6	21.9	24.3	34.1
Start-of-Feeding	20.0	22.7	25.6	27.5
Middle-of-Feeding	19.6	22.4	22.9	27.2
End-of-Feeding	19.1	20.4	23.3	26.0
Middle-of-Anaerobic	19.0	20.9	22.9	25.4
End-of-Anaerobic	18.6	20.9	22.9	25.7
Middle-of-Aerobic	20.5	21.9	23.7	26.1
End-of-Aerobic	19.3	22.3	~~	26.8
Middle-of-Settling	19.5	22.2	~~	27.0
Supernatent	19.4	23.0	24.1	27.1

the ammonia was oxidized to nitrate. Nitrate concentrations were high throughout the study due to the high concentration of TKN in the feed wastewater. Nitrate was removed during the anaerobic (anoxic) stage but the lack of organic matter during this stage most likely limited nitrate removal.

The reactor was also monitored for pH during the different stages of operation. The pH of the feed solution was maintained at approximately 6.7 with a bicarbonate alkalinity of approximately 300-400 mg/l as calcium carbonate. The pH during the various cycles ranged from 7.5 to 7.8. The alkalinity of the supernatant was about 100-150 mg/l as calcium carbonate. Alkalinity of the feed was sufficient to provide good nitrification throughout this phase of the study. The DO concentration was also continuously monitored during the different stages of the reactor operation. The average DO values ranged between 4.5 to 5.5 mg/L during the feed stage; 0.15 to 0.10 mg/L during the anaerobic stage; and 5.5 to 6.0 mg/L during the aeration stage of the reactor operation. The DO was adjusted by changing the flow of air which was measured with the help of a flow meter, attached to the air supply line.

3.3 Range Finding Test Results

At the beginning of the study, it was proposed that AFFF wastewater concentrations be tested at concentrations that might be expected for a worst-case scenario. The worst-case scenario was stipulated by HRSD and was identified as the highest discharge from a Navy hangar occurring at the lowest hourly flow through HRSD's Chesapeake-Elizabeth plant. Consideration of greater dilution factors would be a cause for the District to require containment and subsequent controlled discharge.

The results of preliminary tests that were conducted at the worst case concentration indicated that the motility of microorganisms were affected significantly. Therefore, the range finding tests were performed at lower concentrations of AFFF solutions than the worst-case concentration. Initially, a set of BNR inhibition batch assays were performed with different concentrations of AFFF wastewater in order to determine a range that may be inhibitory to the nitrification process. This range aided in narrowing the span of concentrations to be tested in the further biological nutrient removal inhibition evaluation tests. The concentrations of AFFF used

TABLE 3-4 — Range Finding Test Reactor Components

PARAMETER	CONTROL REACTORS			INHIBITION REACTORS		
	A_1	A_2	A_3	B_1	B_2	B_3
Total Reaction Volume (mL)	6,000	6,000	6,000	6,000	6,000	6,000
Batch MLSS (mg/L)	2,560	2,560	2,560	2,560	2,560	2,560
Seed Biomass Volume (ml)	4,000	4,000	4,000	4,000	4,000	4,000
Effective Wastewater (feed & AFFF) Volume (ml)	2,000	2,000	2,000	2,000	2,000	2,000
AFFF Concentration (ppm)	0	1,050	1,050	1,050	1,050	1,050
AFFF Volume for the simulated wastewater (ml)	0.0	70.0	7.0	4.0	0.70	0.07
Volume of synthetic Feed Solution for the simulated wastewater (mL)	3,000	1,930	1,993	1,996	1,999.3	1,999.93

were 1,050 ppm, 105 ppm, 60 ppm, 10.5 ppm, 1.05 ppm and a control. The reactor components for each AFFF concentration and the control are summarized in Table 3-4 and in Appendix II. The results indicated that nitrification inhibition occurred at AFFF concentrations of 60 ppm, 105 ppm, and 1,050 ppm in the feed wastewater. The results of range finding tests with respect to ammonia nitrogen and COD removal rates are shown in Table 3-5.

3.4 BNR Inhibition Batch Assays

After determining a specific range of AFFF wastewater that exhibited inhibitory effects to the biological nutrient removal process, four concentrations of AFFF were tested in addition to paired controls. During each inhibition testing, one set of triplicate reactors (6-liter volume) were used as control which did not include any AFFF wastewater exposure. The remaining three reactors were used for one specific AFFF concentration. The inhibition concentrations that were tested include 10 ppm, 30 ppm, 50 ppm, and 60 ppm of AFFF in the feed wastewater and mixed liquor from the reference reactor. The results of each concentration tested will be described separately in the following sections. The results of these tests are shown in detail in Appendices III through VI.

3.4.1 Inhibition Test at 60 ppm AFFF Concentration

Triplicate reactors for control and 60 ppm AFFF concentration were set up to observe nitrification inhibition. The conditions of this inhibition test are summarized in Table 3-6. During the testing, significant foaming occurred with the 60 ppm AFFF concentration as compared to the controls however, solids washout were not significant. A thick layer of foam was formed on top of the inhibition reactors which prevented the loss of solids. The ammonia nitrogen removal rates ranged between 97 to 98 percent as shown in Table 3-7. There was no significant nitrification inhibition as compared to the control reactors. The COD removal rates were higher for the AFFF-dosed inhibition reactors ranging between 92 and 95 percent. This higher removal reflects the higher initial COD concentration associated with the AFFF. Oxygen uptake rates (OUR) and SOUR were measured during the inhibition testing. The air supply to each reactor was monitored during the aerated feed and aerobic stage with a submergible dissolved oxygen probe to ensure

TABLE 3-5 — Range Finding Inhibition Test Results

Reactor	AFFF ppm	Initial* NH_3-N mg/L	Final NH_3-N mg/L	% Removal	Initial* NO_3-N mg/L	Final NO_3-N mg/L	Initial COD mg/L	Final COD mg/L	COD Removal %
Feedstock	0								
Reference Reactor	0								
Control	0	8.4	0.1	98.8	29.7	36.9	171	22.0	87.1
AFFF-1	1.05	13.7	1.2	91.2	19.7	34.8	181	44.5	75.4
AFFF-2	10.5	7.5	0.2	97.3	30.6	39.7	267	97.0	63.7
AFFF-3	60	5.2	3.7	28.8	31.6	36.5	718	504.5	29.7
AFFF-4	105	8.1	7.7	4.9	28.9	32.3	1128	827.0	26.7
AFFF-5	1050	13.7	23.8	-73.7	6.0	7.4	9738	3919.5	**

* Initial Values correspond to the measurements taken at the end of feeding stage.

** The COD vials used measured between the ranges 0 to 900 mg/L. Dilutions were not made due to very high levels of COD at this concentration.

TABLE 3-6—BNR Inhibition Reactor 60 ppm AFFF Components

PARAMETER	CONTROL REACTORS			INHIBITION REACTORS		
	A_1	A_2	A_3	B_1	B_2	B_3
Total Reaction Volume (mL)	6,000	6,000	6,000	6,000	6,000	6,000
Batch MLSS (mg/L)	2,540	2,513	2,567	2,353	2,280	2,253
Batch MLVSS (mg/L)	2,387	2,347	2,413	2,207	2,120	2,120
Seed Biomass Volume (ml)	4,000	4,000	4,000	4,000	4,000	4,000
Effective wastewater (feed & AFFF) Volume, ml	2,000	2,000	2,000	2,000	2,000	2,000
AFFF Concentration (ppm)	0	0	0	60	60	60
AFFF Volume for the simulated wastewater (mL)	0.0	0.0	0.0	4.0	4.0	4.0
Volume of Synthetic Feed Solution for the simulated wastewater (mL)	2,000	2,000	2,000	1,996	1,996	1,996

TABLE 3-7 — Nitrification Inhibition at 60 ppm

Reactor	AFFF ppm	*Initial NH_3 - N mg/L	Final NH_3 - N mg/L	% Removal	*Initial NO_3 - N mg/L	Final NO_3 - N mg/L	Initial COD mg/L	Final COD mg/L	COD Removal %
Feedstock	0	30.3	---	---	0.9	---	1931		
Reference Reactor Decant	0	0.3	---	---	103.5	---	127		
Control (A1)	0	8.2	0.21	97.44	70.9	87.8	343	37	89
Control (A2)	0	7.8	0.14	98.21	67.8	87.7	343	37	89
Control (A3)	0	6.9	0.17	97.54	68.6	89.7	343	48	86
AFFF (B1)	60	10.0	0.27	97.30	60.8	84.5	1206.**	97	92
AFFF (B2)	60	10.4	0.23	97.79	58.0	82.5	1206.**	67	95
AFFF (B3)	60	8.5	0.19	97.76	61.0	86.3	1206.**	67	95

* Initial values correspond to the measurements taken at the end of feeding stage.
** Corresponds to the total COD which includes: Reference Reactor decant COD = 127 mg/L, Feedstock COD=1,931 mg/L and AFFF COD = 5,180 mg/L.

that appropriate amount of dissolved oxygen was provided. The results indicated a lower oxygen uptake with the inhibition reactors at 60 ppm AFFF concentration and are shown in Figures 3-1 and 3-2.

3.4.2 Inhibition Test at 50 ppm AFFF Concentration

At 50 ppm AFFF concentration, significant foaming and solids removal from solution were observed. The foam was "lighter" and there was no layered foam as observed in the reactors as seen with the higher 60 ppm AFFF concentration. The solids loss was the most intense of all the inhibition tests as shown in Table 3-8 along with the reactor components. The nitrification inhibition results indicated ammonia nitrogen removal rates ranging from 94 to 96 percent for the control reactors. Nitrification was not inhibited in the inhibition reactors as compared to the controls. The COD removal rates were significantly lower in inhibition reactors than the control reactors which are shown in Table 3-9. The dissolved oxygen measurements during the aerobic stage are also presented in Figures 3-3.

3.4.3 Inhibition Test at 30 ppm AFFF Concentration

The reactor components for this inhibition test are shown in Table 3-10. Loss of solids was also observed in this test in the inhibition reactors as compared to the control reactors potentially due to the nature of the foam formed with this AFFF concentration. The results showed no significant nitrification inhibition . The COD removal rates ranged between 75 to 77 percent in the inhibition reactors and 87 to 90 percent in the control reactors as shown in Table 3-11. The oxygen uptake rates in terms of SOURs are also shown in Figures 3-4 and 3-5.

3.4.4 Inhibition Test at 10 ppm AFFF Concentration

Significantly less foaming and loss of solids were observed with the 10 ppm AFFF concentration. The reactor components and volumes are shown in Table 3-12. Most of the nitrification has already occurred during the aerated feed stage with the ammonia nitrogen concentrations being less than 0.2 mg/L for the control reactors. Even though the ammonia nitrogen removal rates were lower (between 10 and 45 %) for the control reactors, the effluent

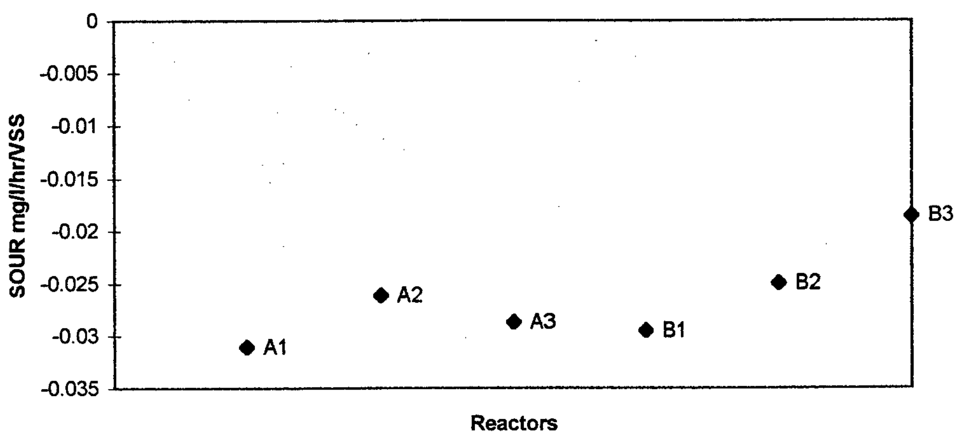


Figure 3-1: Specific Oxygen uptake rates (SOUR's) during the feed stage for 60 ppm AFFF (A--Control, B--Inhibition)

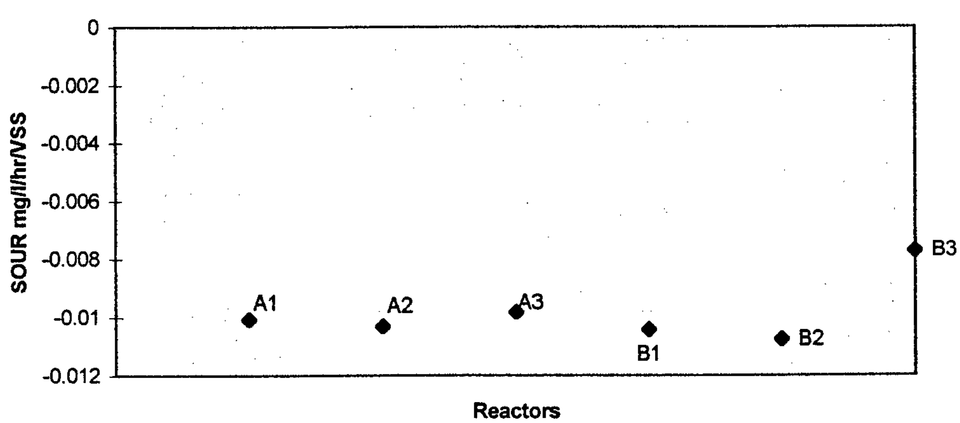


Figure 3-2: Specific Oxygen uptake rates (SOUR's) during the aerobic stage for 60 ppm AFFF (A--Control, B-Inhibition)

TABLE 3-8—BNR Inhibition Reactor Components: 50 ppm AFFF

PARAMETER	CONTROL REACTORS			INHIBITION REACTORS		
	A_1	A_2	A_3	B_1	B_2	B_3
Total Reaction Volume (mL)	6,000	6,000	6,000	6,000	6,000	6,000
Batch MLSS (mg/L)	2,713	2,653	2,680	1,693	1,106	1,213
Batch MLVSS (mg/L)						
Seed Biomass Volume (ml)	4,000	4,000	4,000	4,000	4,000	4,000
Effective wastewater (feed & AFFF) Volume, ml	2,000	2,000	2,000	2,000	2,000	2,000
AFFF Concentration (ppm)	0	0	0	50	50	50
AFFF Volume for the simulated wastewater (mL)	0.0	0.0	0.0	3.3	3.3	3.3
Volume of Synthetic Feed Solution for the simulated wastewater (mL)	2,000	2,000	2,000	1,997	1,997	1,997

TABLE 3-9 — Nitrification Inhibition at 50 ppm

Reactor	AFFF ppm	*Initial NH_3 - N mg/L	Final NH_3 - N mg/L	% Removal	*Initial NO_3 - N mg/L	Final NO_3 - N mg/L	Initial COD mg/L	Final COD mg/L	COD Removal %
Feedstock	0	29.73	---	---	0.7		997		
Reference Reactor Decant	0	0.94	---	---	105.7		79		
Control (A1)	0	3.23	0.19	94.12	82.8	93.1	367	24.1	93.4
Control (A2)	0	2.74	0.19	93.10	84.0	85.6	367	43.2	88.2
Control (A3)	0	3.81	0.15	96.06	84.6	86.1	367	38.4	89.5
AFFF (B1)	50	9.68	0.20	97.93	82.9	96.3	976	315.3	67.7
AFFF (B2)	50	11.88	0.64	94.61	75.6	90.7	976	332.0	66.0
AFFF (B3)	50	11.40	0.09	99.21	77.7	95.5	976	327.2	66.5

* Initial values correspond to the measurements taken at the end of feeding stage.
** Corresponds to the total COD which includes RR decant COD = 79 mg/L, Feedstock COD = 997 mg/L and AFFF COD = 4320 mg/L

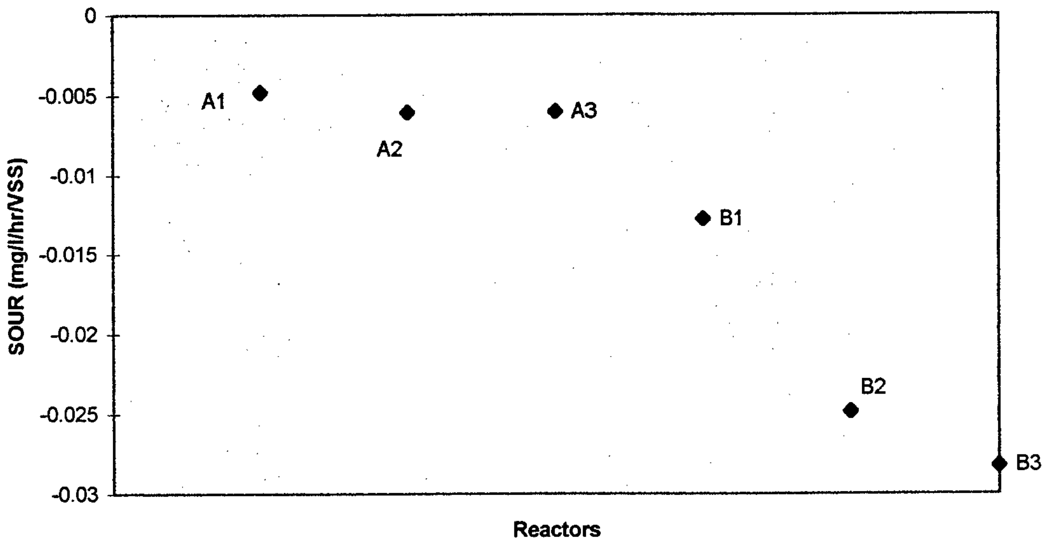


Figure 3-3: Specific Oxygen uptake rates(SOUR's) during the aerobic stage for 50 ppm AFFF (A--Control, B--Inhibition)

Note: The SOUR's are calculated by using VSS, which were calculated by taking the average TSS:VSS ratio for the reference reactor, since they were not actually measured.

TABLE 3-10—BNR Inhibition Reactor Components: 30 ppm AFFF

PARAMETER	CONTROL REACTORS			INHIBITION REACTORS		
	A_1	A_2	A_3	B_1	B_2	B_3
Total Reaction Volume (mL)	6,000	6,000	6,000	6,000	6,000	6,000
Batch MLSS* (mg/L)	2,787	2,760	3,300	2,140	2,560	2,400
Batch MLVSS* (mg/L)	2,573	2,293	2,753	1,927	2,300	2,193
Seed Biomass Volume (ml)	4,000	4,000	4,000	4,000	4,000	4,000
Effective wastewater (feed & AFFF) Volume, ml	2,000	2,000	2,000	2,000	2,000	2,000
AFFF Concentration (ppm)	0	0	0	30	30	30
AFFF Volume for the simulated wastewater (mL)	0.0	0.0	0.0	2.0	2.0	2.0
Volume of Synthetic Feed Solution for the simulated wastewater (mL)	2,000	2,000	2,000	1,998	1,998	1,998

* Reference reactor MLSS = 3,760 mg/L and MLVSS = 3,296 mg/L

TABLE 3-11 — Nitrification Inhibition at 30 ppm

Reactor	AFFF ppm	*Initial NH_3 - N mg/L	Final NH_3 - N mg/L	% Removal	*Initial NO_3 - N mg/L	Final NO_3 - N mg/L	Initial COD mg/L	Final COD mg/L	COD Removal %
Feedstock	0	35.71			0.0		2675		
Reference Reactor Decant	0	0.39			88.2		380		
Control (A1)	0	6.6	0.30	95.4	69.2	84.5	509	66.8	86.9
Control (A2)	0	7.1	0.32	95.5	67.7	84.4	509	61.8	87.9
Control (A3)	0	7.4	0.31	95.8	65.9	83.8	509	51.8	89.8
AFFF (B1)	30	10.7	0.42	96.1	63.5	84.9	948**	232	75.5
AFFF (B2)	30	11.6	0.69	94.0	61.5	79.8	948**	249	73.7
AFFF (B3)	30	10.7	0.66	93.8	63.4	83.7	948**	217	77.1

* Initial values correspond to the measurements taken at the end of the feeding stage.

** Corresponds to the total COD which includes Reference Reactor decant COD = 380 mg/L, Feedstock COD = 2675 mg/L, and AFFF COD = 2,630 mg/L

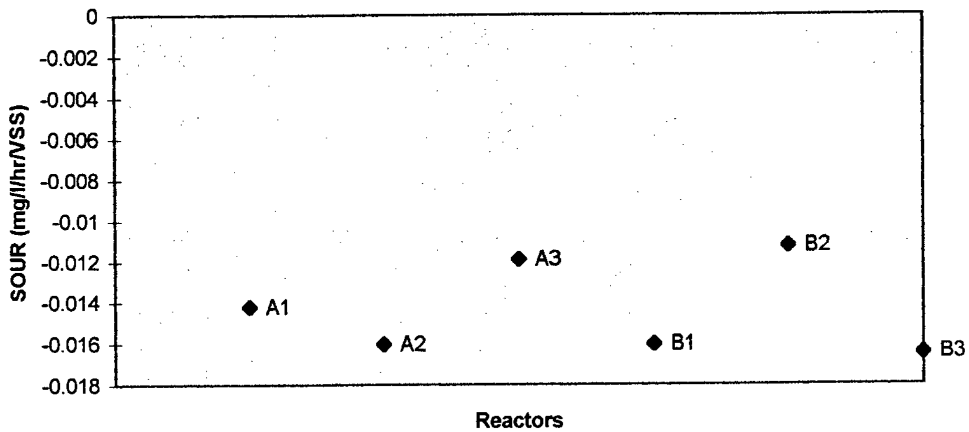


Figure 3-4: Specific Oxygen uptake rates (SOUR's) during the feed stage for 30 ppm AFFF (A--Control, B--Inhibition)

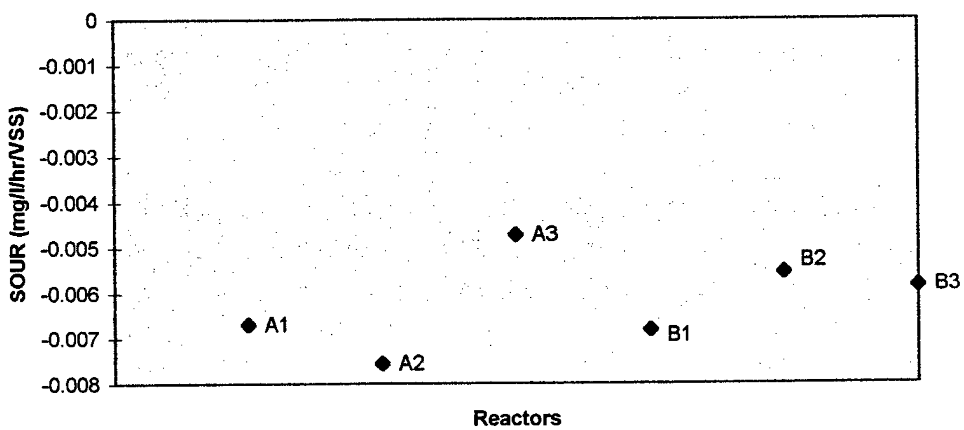


Figure 3-5: Specific Oxygen uptake rates (SOUR's) during the aerobic stage for 30 ppm AFFF (A--Control, B--Inhibition

TABLE 3-12—BNR Inhibition Reactor Components: 10 ppm AFFF

PARAMETER	CONTROL REACTORS			INHIBITION REACTORS		
	A_1	A_2	A_3	B_1	B_2	B_3
Total Reaction Volume (mL)	6,000	6,000	6,000	6,000	6,000	6,000
Batch MLSS * (mg/L)	2,847	2,807	2,747	2,613	2,527	2,600
Batch MLVSS * (mg/L)	2,567	2,553	2,827	2,393	2,333	2,367
Seed Biomass Volume (ml)	4,000	4,000	4,000	4,000	4,000	4,000
Effective wastewater (feed & AFFF) Volume, ml	2,000	2,000	2,000	2,000	2,000	2,000
AFFF Concentration (ppm)	0	0	0	10	10	10
AFFF Volume for the simulated wastewater (mL)	0.0	0.0	0.0	0.7	0.7	0.7
Volume of Synthetic Feed Solution for the simulated wastewater (mL)	2,000	2,000	2,000	1,999	1,999	1,999

* Reference Reactor MLSS = 4,020 mg/L, MLVSS = 3,464 mg/L

ammonia nitrogen values were also less than 0.1 mg/L as shown in Table 3-13. The COD removal for the inhibition reactors were not significantly different than the control reactors possibly due to the low COD of AFFF at the lower concentrations tested. The SOUR measurements during the feed and aerobic stages are shown in Figures 3-6 and 3-7.

3.5 Toxicity Pass-Through Testing

The results of the plant toxicity pass-through tests conducted with the mysid shrimp and sheepshead minnows did not exhibit any pass-through toxicity. The response measured during the acute toxicity tests was survival over the exposure period. The toxicity test results for the samples collected at the end of each inhibition testing from the reactors with and without AFFF had LC_{50} values greater than 100 percent for both test organisms as shown in Table 3-14. The only sample that exhibited consistent toxicity was the influent feed to the reactors which was attributed to the high ammonia concentrations present in the feed mix which ranged from 30 to 35 mg/L of NH_3-N. Acute toxicity test data are shown in Appendix VII.

TABLE 3-13 — Nitrification Inhibition at 10 ppm

Reactor	AFFF ppm	*Initial NH_3 - N mg/L	Final NH_3 - N mg/L	% Removal	*Initial NO_3 - N mg/L	Final NO_3 - N mg/L	Initial COD mg/L	Final COD mg/L	COD Removal %
Feedstock	0	10.61			0.0		2396		
Reference Reactor Decant	0	0.22			85.4		247		
Control (A1)	0	0.10	0.09	10.0	78.6	76.9	441	63.2	85.7
Control (A2)	0	0.14	0.09	35.7	79.8	76.0	441	55.3	87.4
Control (A3)	0	0.20	0.11	45.0	78.6	76.7	441	57.9	86.9
AFFF (B1)	10	1.05	0.08	92.4	69.4	76.2	596**	118	80.2
AFFF (B2)	10	0.62	0.11	82.3	73.4	79.4	596**	116	80.6
AFFF (B3)	10	0.92	0.12	87.0	72.2	76.4	596**	123	79.3

* Initial values correspond to the measurements taken at the end of feeding stage. (end of 2 hours)

** Corresponds to the total COD which includes Reference Reactor Decant = 2,396 mg/L, Feedstock COD = 247 mg/L and AFFF COD = 1,608 mg/L

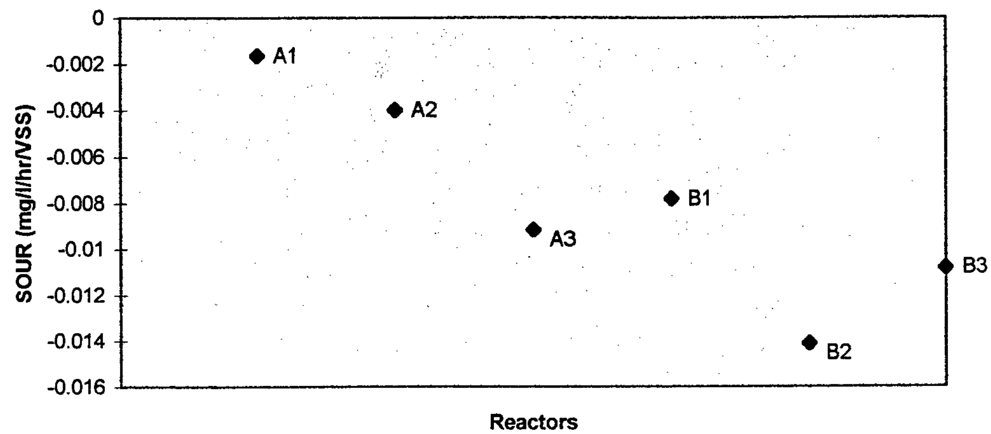


Figure 3-6: Specific Oxygen uptake rates (SOUR's) during the feed stage for 10 ppm AFFF (A--Control, B--Inhibition)

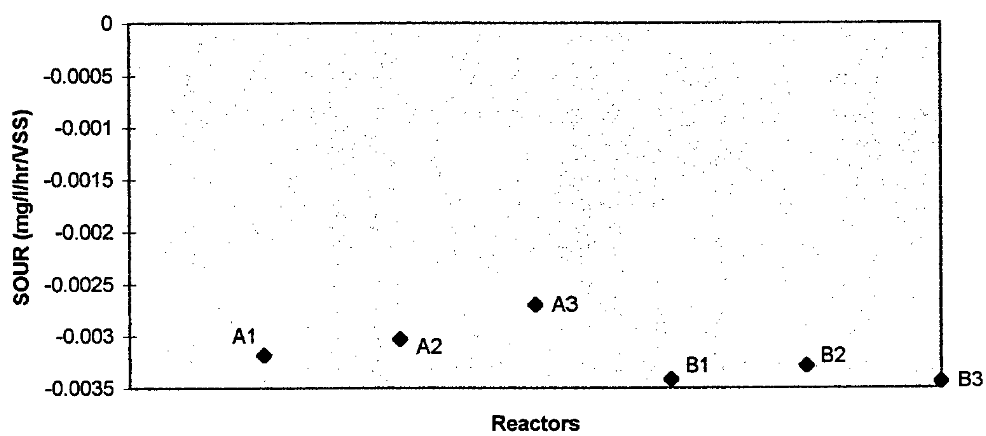


Figure 3-7: Specific Oxygen uptake rates (SOUR's) during the aerobic stage for 10 ppm AFFF (A--Control, B--Inhibition)

Table 3.14: Summary of the Toxicity Testing for the Inhibition tests

AFFF Conc,(ppm)	Date of test	Sample	LC50	
			Fathead Minnow	Mysid Shrimp
10	3/11/97	Feedstock	< 6.25	31
		R.R.Mix Liquor	>100	>100
		Control A1	>100	>100
		Control A2	>100	>100
		Control A3	>100	>100
		Inhibition B1	>100	>100
		Inhibition B2	>100	>100
		Inhibition B3	>100	>100
30	3/19/97	Feedstock	17.7	52
		R.R.Mix Liquor	>100	>100
		Control A1	>100	>100
		Control A2	>100	>100
		Control A3	>100	>100
		Inhibition B1	>100	>100
		Inhibition B2	>100	>100
		Inhibition B3	>100	>100
50	2/11/97	Feedstock	19.5	35
		R.R.Mix Liquor	>100	>100
		Control A1	>100	>100
		Control A2	>100	>100
		Control A3	>100	>100
		Inhibition B1	>100	>100
		Inhibition B2	>100	>100
		Inhibition B3	>100	>100
60	3/25/97	Feedstock	33	34
		R.R.Mix Liquor	>100	>100
		Control A1	>100	>100
		Control A2	>100	>100
		Control A3	>100	>100
		Inhibition B1	>100	>100
		Inhibition B2	>100	>100
		Inhibition B3	>100	>100

4.0 DISCUSSION

The results of the range-finding tests indicated that concentrations of AFFF higher than 60 ppm clearly exhibited significant potential to impact nitrification. For the lower AFFF concentrations in the range finding tests, the ammonia nitrogen concentrations in the supernatant were 0.1 mg/l for the control, 1.2 mg/L for 1.05 ppm AFFF solution, and 0.2 mg/L for 10.5 ppm AFFF solution indicating little or no inhibition as seen in Figure 4-1. For AFFF solutions of 60 ppm and above, significant nitrification inhibition occurred in the wastewater as compared to the control reactors. Note that the increasing ammonia concentrations at 1,050 ppm indicate conversion of organic nitrogen to ammonia occurred. Nitrate production rates were also in accordance with the ammonia removal rates, and an excellent mass balance on the nitrogen species was observed overall. During the range finding tests, the motility of microorganisms were also observed under the microscope for each AFFF concentration. There were no apparent changes observed between 1 and 60 ppm AFFF concentrations. However, at concentrations greater than 60 ppm AFFF, motility of microorganisms was impacted significantly. This observation is consistent with the nitrification inhibition results. Therefore, AFFF concentrations equal to and lower than 60 ppm were tested in the inhibition study to better delineate the effects of AFFF at concentrations approaching nitrification inhibition levels.

The COD removal rates decreased with increasing AFFF concentrations from as high as 87% in the control reactor to 27 % at the greatest AFFF concentration. While the percent COD removal decreased with increasing AFFF concentration, the amount of COD removed actually increased (on a mg/L basis). This observation is a direct result of the addition of COD associated with the AFFF. For example, the COD of 300 ppm AFFF solution (1% AFFF concentrate) was measured to be 8,200 mg/L. This additional COD contributed by the AFFF had the effect of increasing the initial COD of the wastewater as the AFFF concentrations increased.

The results of the nitrification inhibition study showed that the AFFF concentrations tested in the range between 10 ppm to 60 ppm did not show any significant inhibition to biological nitrification. The effluent from each reactor did not exhibit any pass-through toxicity as well (Appendix VII). The intensity of foaming increased with the increasing AFFF concentrations.

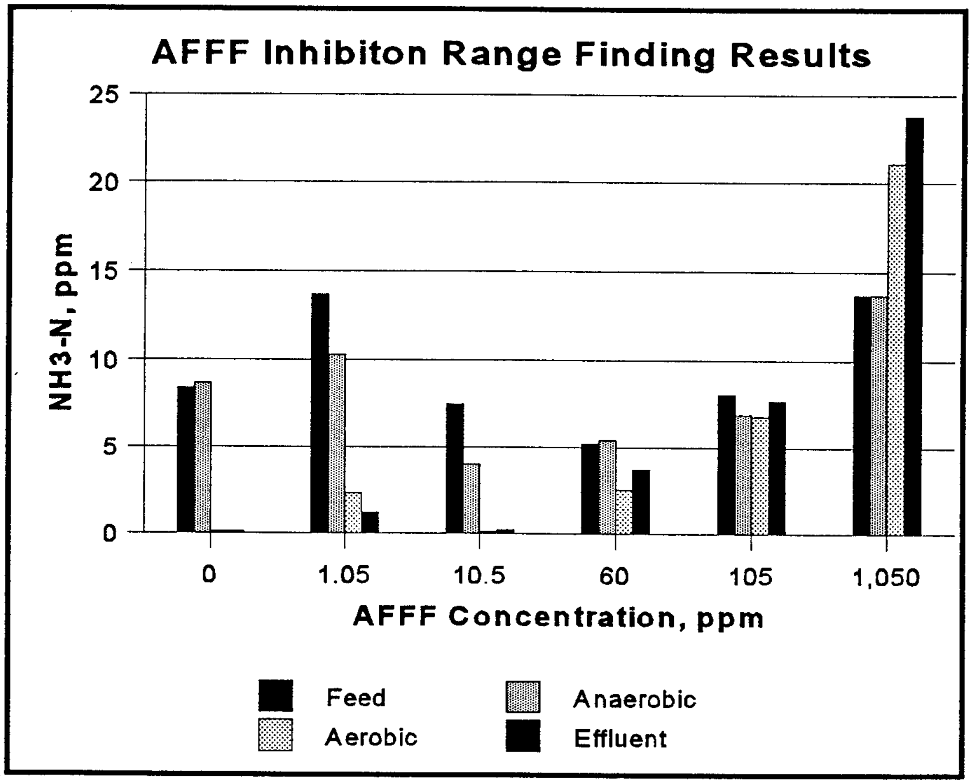


Figure 4-1. AFFF Inhibition Study Range Finding Results

The loss of solids from the reactors was associated with the foaming density which was in turn related to the amount of air supplied and bubble size formed in each reactor. At AFFF concentrations between 10 ppm to 50 ppm, the loss of solids increased. However, at 60 ppm, the foaming was so much denser that it did not allow solids carryover from the reactors. Uninhibited nitrification was also observed among the reactors that had excessive foaming. Some reductions in percent COD removal were seen as the AFFF concentrations increased. However, as indicated above these reactors actually removed more COD.

The results showed no significant nitrification inhibition for any of the AFFF concentrations tested as compared to the control reactors as shown in Figures 4-2a and 4-2b. It was observed that nitrification started to occur at the beginning of the aerated feed stage for all of the reactors and that significant ammonia removal occurred during this stage for both control and inhibition reactors at all AFFF concentrations tested. At the end of the anaerobic cycle, some of the ammonia nitrogen was released in all tests, possibly due to bacterial reduction of nitrates and nitrites or organic nitrogen conversion to ammonia. The ammonia nitrogen concentrations decreased significantly at the end of the aerobic cycle and in the effluent for each reactor, exhibiting no nitrification inhibition. The nitrate data for each inhibition test also supported the occurrence of nitrification in the reactors. The nitrification occurring in each reactor can also be seen in Figure 4-3 which shows the ammonia nitrogen removal during different stages for each AFFF concentration tested. The effluent from each reactor exhibited greater than 98 percent ammonia removal.

There was significant COD removal observed for each AFFF concentration tested as well. However, the percent COD removal in the inhibition reactors was less than that of the control reactors and the percent COD reduction decreased with increasing AFFF concentrations in the inhibition reactors. These results are shown in Figures 4-4a and 4-4b. During this study, there was an increase in the foaming in the inhibition reactors with increased AFFF concentrations. This foaming was specifically heavy during the aerated feed stage of the inhibition testing. The major influence on the reactor performance was the loss of solids (MLSS) at higher AFFF concentrations. This loss of solids removed microbical cells from solution and likely contributed

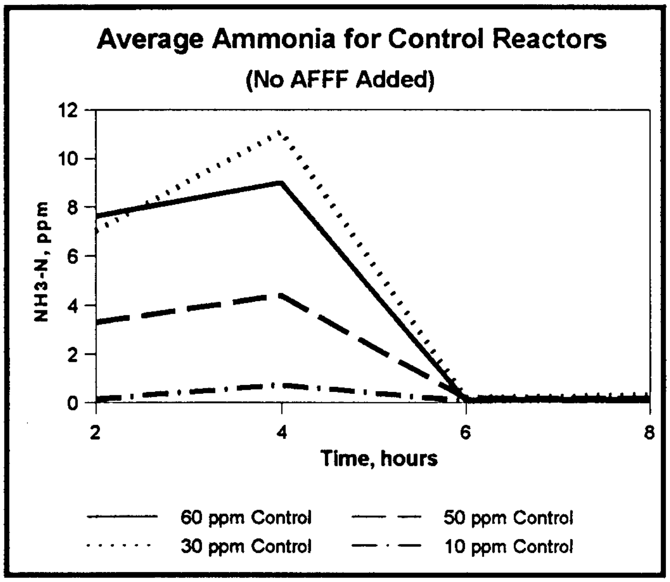


Figure 4-2a. Average Ammonia Concentrations for Control Reactors

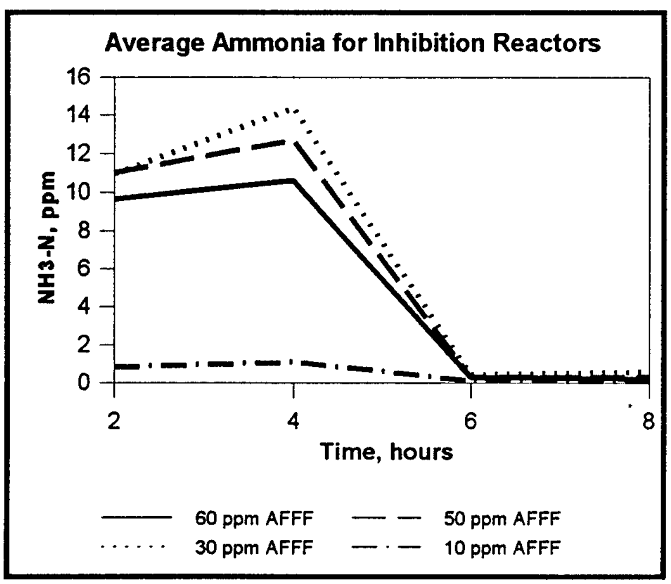


Figure 4-2b. Average Ammonia Concentrations for Inhibition Reactors

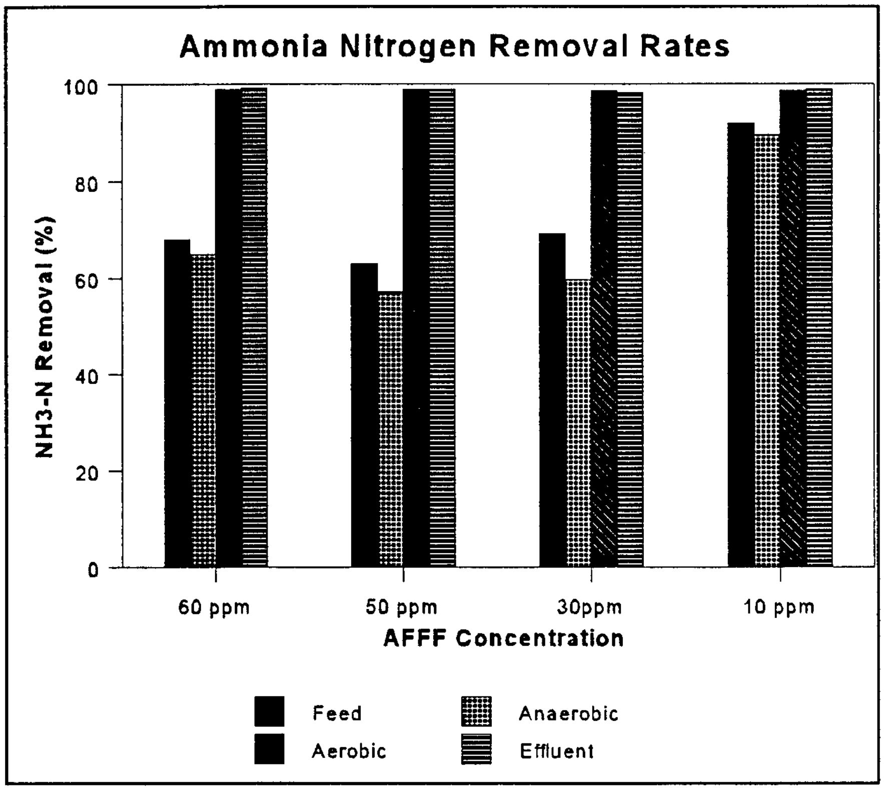


Figure 4-3. Average Ammonia Nitrogen Removal Rates for the Inhibition Reactors

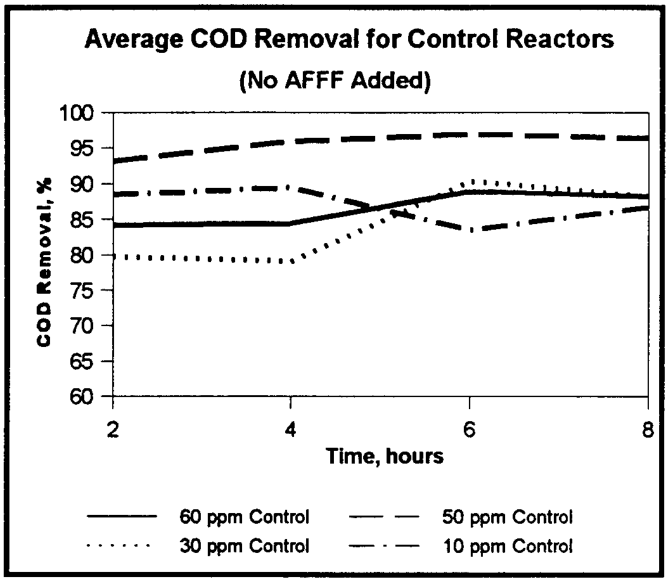


Figure 4-4a. Average COD Removal Rates for the Control Reactors

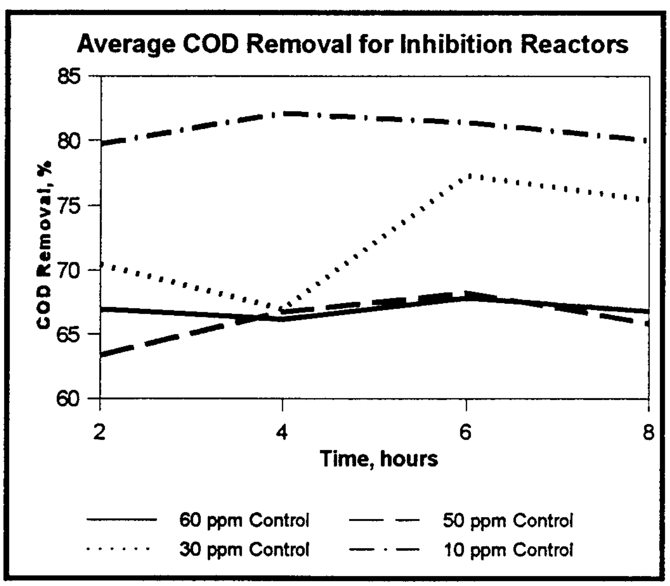


Figure 4-4b. Average COD Removal Rates for the Inhibition Reactors

to the lower percent COD removals. However, even at lower MLSS concentrations, the total amount of COD removed exceeded that of the controls.

Organo-fluoride compounds are known to be a constituent of AFFF and it was suspected a priori that decomposition of the organo-fluoride compounds would likely occur resulting in accumulations of inorganic fluoride in solution. If this reaction occurs, then an increase in inorganic fluoride should be observed upon treatment of a water containing AFFF.

Fluoride measurements were conducted for controls and the AFFF wastewater at two-hour intervals and then examined for fluoride release. In the control samples, the fluoride concentrations remained essentially unchanged during the testing (Figure 4-5a) as expected with no organo fluoride compounds present. The fluoride measured for these samples reflects the "background" inorganic fluoride concentration and when subtracted from the fluoride concentrations measured for the AFFF-dosed wastewater (Figure 4-5b) will reflect the fluoride released from organic compounds (Figure 4-6). The linear relationship up to 50 ppm AFFF signifies that organo-fluoride compounds are being decomposed in proportion to the AFFF concentration. The low release of F for the 60 ppm AFFF wastewater suggests some interference in fluoride release. This interference may be an inhibition of the microorganisms that were capable of decomposing these compounds or evidence of selective substrate utilization (i.e. diauxic growth) where microorganism were consuming other preferable compounds before selecting organo-fluoride compounds.

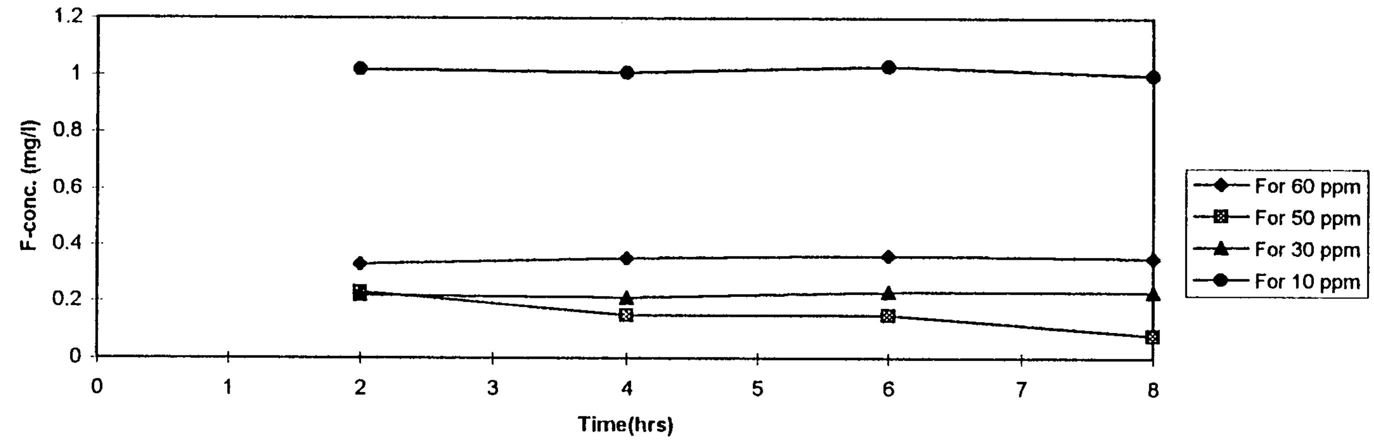


Figure 4-5a. Average inorganic Fluoride concentration for controls

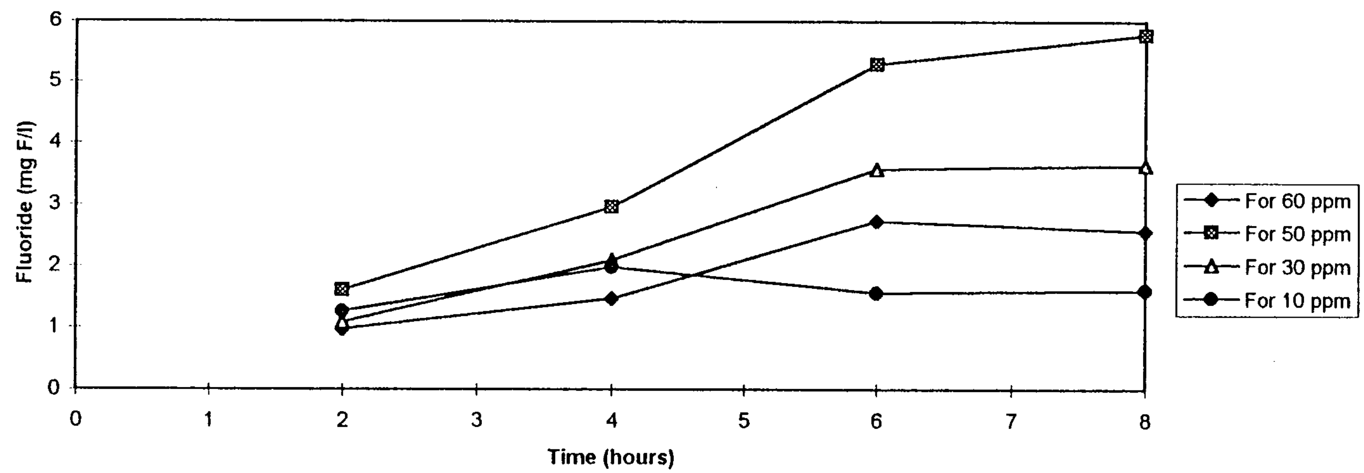


Figure 4-5b. Inorganic Fluoride measurements as a function of reaction time

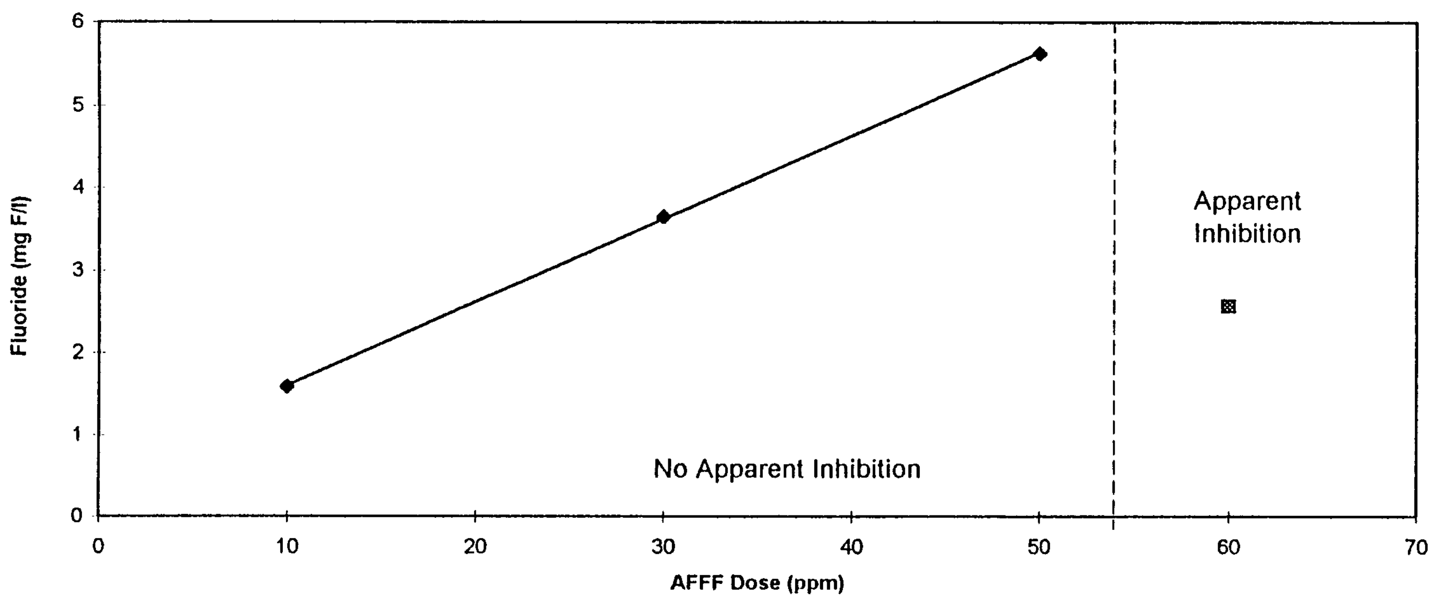


Figure 4-6. Fluoride released as a function of AFFF dose for inhibition reactors

5.0 CONCLUSIONS

The results of the nitrification inhibition study showed that the AFFF concentrations tested in the range between 10 ppm to 60 ppm did not show any inhibition to biological nitrification. The range finding tests indicated nitrification inhibition did occur above 60 ppm AFFF. Microscopic observations also showed significant impacts on the motility of microorganisms at concentrations greater than 60 ppm AFFF.

The reference reactor did not develop biological P removal due to the rapid consumption of COD during the aerobic feed stage. This occurrence most likely prevented significant production of acetate during anaerobic stage which is essential for developing poly P bacteria. It is likely that with an anaerobic feed cycle, the reactors would have exhibited P removal. Loss of biological solids from the reactors increased with increasing AFFF concentrations up to 50 ppm, however, at 60 ppm very little solids were lost from the reactors. The intensity of foaming increased with the increasing AFFF concentrations however, uninhibited nitrification was also observed among the reactors that had excessive foaming. Some reductions in the percent COD removal were observed as the AFFF concentrations increased.

Fluoride release suggested that organo fluoride compounds decomposed up to 50 ppm and some inhibition was observed at 60 ppm Acute toxicity test results showed that the effluent from each inhibition reactor did not exhibit any pass-through toxicity as well.

Overall, the results of Phase 1A study indicated that AFFF solutions discharged into the wastewater at concentrations 60 ppm or below did not exhibit any inhibitory effect to biological nitrification and pass through toxicity.

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Appendix I

AFFF MSDS

and

Technical Information Bulletin

3M Specialty Chemicals Division

3M Center
St. Paul, MN 55144-1000
612 733 1110

3M

April 29, 1997

Ms. Mujde Erten-Unal
Old Dominion University
Department of Civil and Environmental Engineering
Kaufman Hall 133A
Norfolk, VA 23529-0241

FAX: 757-683-5354

Dear Ms. Erten-Unal:

At your request, I am providing you with information (for your wastewater characterization study) for the various compounds present in FC-203CE Lightwater™ Brand Aqueous Film Forming Foam. The enclosed list of compounds identified in Table 2 is based on those supplied by you on April 14.

I have also enclosed a copy of the technical information pertaining to this product.

If I can be of further assistance to you, please feel free to call me at 612-778-7518.

Sincerely,

Pam Wolf

Pamela A. Wolf

PAW/jle
Enclosures

cc: C.J. Bierbrauer - 236-2B-03
S.K. Loushin - 236-1B-10
R.E. Ottman - 236-2A-01
L.J. Pickett - 53-3S-02
P.E. Rivers - 236-1B-07

Table 2

Parameter	Comments
BOD_5	See MSDS
COD	See MSDS
TSS	Not a specification requirement
CL_2, residual	Not intentionally added or known to be present
pH, conventional	See Technical information
Total phosphorus	Not intentionally added or known to be present
TKN	Not a specification requirement
Chlorides	Not intentionally added or known to be present
TOC	Not a specification requirement
NH_3, total	Not intentionally added or known to be present
Alkalinity	Not a specification requirement
TDS	Not intentionally added or known to be present
Metals	Not intentionally added or known to be present
Cyanide, by distillation	Not intentionally added or known to be present
Pesticides and PCB's	Tolyl triazole (CAS# 29385-43-1)*
Volatile Organics	Butyl carbitol (CAS# 112-34-5)*
Semi-Volatile Organics	Not intentionally added or known to be present
Acrolein	Not intentionally added or known to be present
Acrylonitrile	Not intentionally added or known to be present
1,2 - diphenylhydrazine	Not intentionally added or known to be present
Arochlor (both)	Not intentionally added or known to be present
2,3,7,8 - tetrachlorodibenzo-p-dioxin	Not intentionally added or known to be present
MEK	Not intentionally added or known to be present
MIBK	Not intentionally added or known to be present
Xylenes	Not intentionally added or known to be present
Acetone	Not intentionally added or known to be present
Surfactant	Trade Secret (cannot be disclosed)
Fluorohydrocarbons	Not intentionally added or known to be present
Fluoride	May be present
Butyl Carbitol	See Volatile Organics

*See MSDS for percent present in product.

Light Water™

Technical Information

AFFF
FC-203CE

Description

Light Water™ AFFF* is a synthetic firefighting foam concentrate designed for use on non-polar, hydrocarbon hazards. When proportioned with water and applied with conventional foam or water/fog equipment, Light Water™ AFFF provides excellent control and extinguishment of Class B fires by spreading a vapor-sealing film over the liquid fuel. This vapor seal inhibits reflash even when the foam blanket is ruptured and also allows the product to be used to secure non-ignited spills. Light Water™ AFFF provides excellent penetrating and wetting qualities when used on Class A fires. This is important when extinguishing deep-seated fires in wood, paper, rubber tires and other ordinary combustibles.

Typical Properties (Not for specification purposes)
Nominal use concentration: 3%
Specific gravity @ 77°F (25°C): 1.025
Density: 8.54 lbs/gal.
Viscosity @ 77°F (25°C): 4.8 centistokes
40°F (4.4°C): 10.2 centistokes
Minimum use temperature: 35°F (1.7°C)
Storage temperature: 35° - 120°F (1.7° - 49°C)
Freeze point: 25°F (-4°C)
pH @ 77°F (25°C): 8
Appearance: Amber liquid

Applications

Light Water™ AFFF can be used with conventional foam equipment with fresh, sea or brackish water. Self-educting foam nozzles and foam nozzles with in-line eductors are among the most common types of hardware for application.

In addition to its use in aspirating foam equipment, Light Water™ AFFF can be dispensed effectively through non-aspirating equipment including fog nozzles, water spray devices and standard sprinklers. Light Water™ AFFF is listed by UL for use with handline nozzles, foam chambers for top side protection, forcing foam makers for subsurface injection and standard sprinkler heads. Light Water™ AFFF exceeds U.S. military specification MIL F24385C and is listed on the U.S. Military Q.P.L. (Qualified Product List).

Light Water™ AFFF is effective in subsurface injection systems for non-water soluble hydrocarbons. Subsurface injection is safe and reliable for fixed protection of storage tanks.

Light Water™ AFFF may be applied to fires simultaneously with dry chemical firefighting agents because the two are compatible.

Features

Effective: Rapid extinguishment reduces the chances of dangerous incidents and reduces the risk to property and equipment. Light Water™ AFFF also prevents reflash and burnback, which are major causes of injuries. The securing action of Light Water™ AFFF minimizes the fire hazard during cleanup of flammable liquid spills.

Reliable: Light Water™ AFFF can be stored for virtually an indefinite period of time in approved equipment and systems. NFPA 11 recommends annual inspection of all foam systems.

Economical: Light Water™ AFFF offers faster extinguishment than protein based foams, so less agent is required in training and actual fire emergencies. Its wide range of applications reduces or eliminates the need to inventory other special type agents.

*Aqueous Film Forming Foam

98-0211-4266-0

3M Industrial Chemical Products Division
Building 223-6S-04, 3M Center
St. Paul, MN 55144-1000

3M

Environmental/Toxicological Properties

Standardized tests are conducted as an ongoing program to evaluate and assess the impact of Light Water™ AFFF on humans and the natural environment. Based on test results, Light Water™ AFFF is biodegradable, low in toxicity and can be treated in biological treatment systems. In its concentrate form, Light Water™ AFFF was found to be a slight eye and skin irritant, but as a foam solution, there are no noticeable negative effects. Tests and actual use situations have shown that animal and aquatic life are not adversely affected.

Storage

Light Water™ AFFF may be stored in its shipping container without change in its original physical or chemical characteristics. It does not show significant sedimentation or precipitation in storage or after temperature cycling. Freezing and thawing have no effect on performance and the concentrate proportions satisfactorily in ordinary equipment at temperatures above 32°F. Freeze-thaw cycling may cause slight stratification which may be overcome with moderate agitation. Premix solutions in fresh water may be stored long term for ready use at temperatures above freezing.

Packaging

Light Water™ AFFF is available in 5 gallon pails or 55 gallon drums.

Representative Locations

Anchorage
11151 Calaska Circle
Anchorage, AK 99515
907/522-5200

Atlanta
2860 Bankers Industrial Drive
Atlanta, GA 30360
404/447-7096
404/447-7043

Boston
155 Fourth Avenue
Needham Heights, MA 02194
617/455-7254

Chicago
908 N. Elm Street
Hinsdale, IL 60521
312/496-6604
312/920-1000

Dallas
2121 Santa Anna Avenue
Dallas, TX 75228
214/324-8172

Honolulu
4443 Malaai Street
Honolulu, HI 96818
808/422-2721

London, Ontario
P.O. Box 5757, Terminal A
London, Ontario N6A4T1
519/451-2500

24 Hour Emergency Service
612/733-1110

Los Angeles
6023 So. Garfield Avenue
Los Angeles, CA 90040
213/726-6361

St. Paul
223-6S-04, 3M Center
St. Paul, MN 55144
612/733-1710 (Ordering Product)
612/736-6055
612/733-1683

San Francisco
1241 E. Hillsdale Blvd.
Foster City, CA 94404
415/571-6700

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Seller's and manufacturer's only obligation shall be to replace such quantity of the product proved to be defective. Before using, user shall determine the suitability of the product for its intended use, and user assumes all risk and liability whatsoever in connection there within. NEITHER SELLER NOR MANUFACTURER SHALL BE LIABLE EITHER IN TORT OR IN CONTRACT FOR ANY LOSS OR DAMAGE, DIRECT, INCIDENTAL, OR CONSEQUENTIAL, ARISING OUT OF THE USE OF OR THE INABILITY TO USE THE PRODUCT. No statement or recommendation not contained herein shall have any force or effect unless in an agreement signed by officers of seller and manufacturer.

Issued 12/87

3M Industrial Chemical Products Division
Building 223-6S-04, 3M Center
St. Paul, MN 55144-1000

MATERIAL SAFETY DATA SHEET

3M
3M Center
St. Paul, Minnesota
55144-1000
(612) 733-1110

DIVISION: SPECIALTY CHEMICALS DIVISION
TRADE NAME:
FC-203CE LIGHT WATER(TM) Brand Aqueous Film Forming Foam
ID NUMBER/U.P.C.:

CF-1206-0242-4	-	-	-	ZF-0002-0095-4	-	-	-
ZF-0002-0137-4	-	-	-	ZF-0002-0413-9	-	-	-
ZF-0002-0415-4	-	-	-	ZF-0002-0444-4	-	-	-
ZF-0002-4660-1	-	-	-	ZF-0002-4661-9	-	-	-

ISSUED: February 19, 1997
SUPERSEDES: October 24, 1996
DOCUMENT: 10-3817-3

1. INGREDIENT

INGREDIENT	C.A.S. NO.	PERCENT	
WATER....................................	7732-18-5	57.0	- 63.0
DIETHYLENE GLYCOL BUTYL ETHER...........	112-34-5		30.0
ALKYL SULFATE SALTS(2) +(5154P,5166P)...	TradeSecret	1.0	- 5.0
AMPHOTERIC FLUOROALKYLAMIDE DERIVATIVES(2) +(5130P)...............	TradeSecret	1.0	- 5.0
SYNTHETIC DETERGENT +(5037P)............	TradeSecret		2.1
PERFLUOROALKYL SULFONATE SALTS(5) +(5142P)............................	TradeSecret	1.0	- 5.0
TOLYL TRIAZOLE..........................	29385-43-1		0.05

New Jersey Trade Secret Registry (EIN) 04499600-+

This product contains the following toxic chemical or chemicals subject to the reporting requirements of Section 313 of Title III of the Emergency Planning and Community Right-To-Know Act of 1986 and 40 CFR Part 372:
DIETHYLENE GLYCOL BUTYL ETHER

2. PHYSICAL DATA

BOILING POINT:................. ca. 100 C
VAPOR PRESSURE:................ ca. 17.0 mmHg
Calc. @ 20 C
VAPOR DENSITY:................. ca. 0.88 Air=1
Calc. @ 20 C

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

2. PHYSICAL DATA (continued)

EVAPORATION RATE:.............. < 1 BuOAc=1
SOLUBILITY IN WATER:........... Miscible
SPECIFIC GRAVITY:.............. ca. 1.03 Water=1
PERCENT VOLATILE:.............. ca. 90 %
pH:............................ ca. 8.5
VISCOSITY:..................... N/D
MELTING POINT:................. N/A

APPEARANCE AND ODOR:
Clear, amber colored liquid.

3. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT:................... None (Setaflash CC)
FLAMMABLE LIMITS - LEL:........ N/A
FLAMMABLE LIMITS - UEL:........ N/A
AUTOIGNITION TEMPERATURE:...... N/A

EXTINGUISHING MEDIA:
Product is a fire-extinguishing agent.

SPECIAL FIRE FIGHTING PROCEDURES:
Not applicable

UNUSUAL FIRE AND EXPLOSION HAZARDS:
See Hazardous Decomposition section for products of combustion.

4. REACTIVITY DATA

STABILITY: Stable

INCOMPATIBILITY - MATERIALS/CONDITIONS TO AVOID:
Not applicable.

HAZARDOUS POLYMERIZATION: Hazardous polymerization will not occur.

HAZARDOUS DECOMPOSITION PRODUCTS:
Carbon Monoxide and Carbon Dioxide, Hydrogen Fluoride

Thermal decomposition of usage concentrations does not present a hazard.

5. ENVIRONMENTAL INFORMATION

SPILL RESPONSE:
Refer to other sections of this MSDS for information regarding physical and health hazards, respiratory protection, ventilation, and personal protective equipment. In the U.S.A., call (612) 733-1110 or (612) 733-6100 for 24-hour spill assistance. Contain spill. Cover with absorbent material. Collect spilled material. Clean up residue. Place in a U.S. DOT-approved container.

RECOMMENDED DISPOSAL:
Slowly discharge spent solutions and small quantities (less than 5 gal.(19 L)) to a wastewater treatment system. Reduce discharge rate if foaming occurs. Incinerate in an industrial or commercial facility. Combustion products will include HF. Dispose of completely absorbed waste product in a facility permitted to accept chemical wastes.

ENVIRONMENTAL DATA:
Chemical Oxygen Demand (COD):0.740 g/g; 5-Day Biochemical Oxygen Demand (BOD5): 0.091 g/g; 20-Day (BOD20): 0.680 g/g; 20-Day BOD/COD: 0.89; 96-Hr LC50, Fathead minnow (Pimephales promelas): >1,000 mg/L; 48-Hr EC50, Daphnia magna: >1,000 mg/L; 96-Hr LC50, Killifish (Fundulus heteroclitus): 1,400 mg/L continuous flow; 5-Min. and 30-Min. EC50, Photobacterium phosphoreum (Microtox System): 370 mg/L and 230 mg/L respectively. 3-Hr- EC50, Activated Sludge (OECD Method 209): >1,000 mg/L.

REGULATORY INFORMATION:
Volatile Organic Compounds: 309 gms/liter South Coast Air Quality Mgmt Dist Method Calc. @ 20 C.
VOC Less H2O & Exempt Solvents: N/A.

The components of this product are in compliance with the chemical registration requirements of: TSCA, EINECS, CDSL, AICS, MITI.

EPCRA HAZARD CLASS:
FIRE HAZARD: No PRESSURE: No REACTIVITY: No ACUTE: Yes CHRONIC: Yes

6. SUGGESTED FIRST AID

EYE CONTACT:
Immediately flush eyes with large amounts of water for at least 15 minutes. Get immediate medical attention.

SKIN CONTACT:
Flush skin with large amounts of water. If irritation persists, get medical attention.

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6. SUGGESTED FIRST AID (continued)

INHALATION:
If signs/symptoms occur, remove person to fresh air. If signs/symptoms continue, call a physician.

IF SWALLOWED:
Drink two glasses of water. Call a physician.

---

7. PRECAUTIONARY INFORMATION

EYE PROTECTION:
Avoid eye contact with vapor, spray, or mist. Wear vented goggles.

SKIN PROTECTION:
Avoid skin contact. Wear appropriate gloves when handling this material. A pair of gloves made from the following material(s) are recommended: butyl rubber.

RECOMMENDED VENTILATION:
Use with adequate dilution ventilation.

RESPIRATORY PROTECTION:
Avoid breathing of vapors, mists or spray. Select one of the following NIOSH approved respirators based on airborne concentration of contaminants and in accordance with OSHA regulations: Half-mask organic vapor respirator with dust/mist prefilter.

PREVENTION OF ACCIDENTAL INGESTION:
Do not eat, drink or smoke when using this product. Wash exposed areas thoroughly with soap and water. Wash hands after handling and before eating.

RECOMMENDED STORAGE:
Store in a cool place. Store away from heat. Store out of direct sunlight. Keep container dry. Keep container in well-ventilated area.

FIRE AND EXPLOSION AVOIDANCE:
Keep container tightly closed. Nonflammable.

OTHER PRECAUTIONARY INFORMATION:
No smoking: Smoking while using this product can result in contamination of the tobacco and/or smoke and lead to the formation of the hazardous decomposition products mentioned in section 4 of this MSDS.

HMIS HAZARD RATINGS: HEALTH: 2 FLAMMABILITY: 0 REACTIVITY: 0
PERSONAL PROTECTION: X (See precautions, section 7.)

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

7. PRECAUTIONARY INFORMATION (continued)

EXPOSURE LIMITS

INGREDIENT	VALUE	UNIT	TYPE	AUTH	SKIN*
WATER	NONE	NONE	NONE	NONE	
DIETHYLENE GLYCOL BUTYL ETHER	35	PPM	TWA	CMRG	
ALKYL SULFATE SALTS(2) +(5154P, 5166P)	NONE	NONE	NONE	NONE	
AMPHOTERIC FLUOROALKYLAMIDE DERIVATIVES(2) +(5130P)	NONE	NONE	NONE	NONE	
SYNTHETIC DETERGENT +(5037P)	NONE	NONE	NONE	NONE	
PERFLUOROALKYL SULFONATE SALTS(5) +(5142P)	0.1	MG/M3	TWA	3M	Y
TOLYL TRIAZOLE	NONE	NONE	NONE	NONE	

* SKIN NOTATION: Listed substances indicated with 'Y' under SKIN refer to the potential contribution to the overall exposure by the cutaneous route including mucous membrane and eye, either by airborne or, more particularly, by direct contact with the substance. Vehicles can alter skin absorption.

SOURCE OF EXPOSURE LIMIT DATA:
- 3M: 3M Recommended Exposure Guidelines
- CMRG: Chemical Manufacturer Recommended Exposure Guidelines
- NONE: None Established

8. HEALTH HAZARD DATA

EYE CONTACT:
Moderate Eye Irritation: signs/symptoms can include redness, swelling, pain, tearing, and hazy vision.

SKIN CONTACT:
Lung Inflammation: Product contains surfactants which have been shown in animal studies to cause lung inflammation resulting from prolonged skin contact. Signs/symptoms can include coughing and shortness of breath.

Mild Skin Irritation (after prolonged or repeated contact): signs/symptoms can include redness, swelling, and itching.

Prolonged or repeated exposure may cause:

May be absorbed through the skin in harmful amounts.

INHALATION:
Single overexposure, above recommended guidelines, may cause:

Central Nervous System Depression: signs/symptoms can include

8. HEALTH HAZARD DATA (continued)

headache, dizziness, drowsiness, incoordination, slowed reaction time, slurred speech, giddiness and unconsciousness.

Irritation (upper respiratory): signs/symptoms can include soreness of the nose and throat, coughing and sneezing.

IF SWALLOWED:
Ingestion is not a likely route of exposure to this product.

Ingestion may cause:

Aspiration Pneumonitis: signs/symptoms can include coughing, difficulty breathing, wheezing, coughing up blood and pneumonia, which can be fatal.

OTHER HEALTH HAZARD INFORMATION:
A 3M Product Toxicity Summary Sheet is available.

SECTION CHANGE DATES

PRECAUTIONARY INFO. SECTION CHANGED SINCE October 24, 1996 ISSUE

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

3M Product Environmental Data Sheet

Form 14705 - H - PWO

Environmental Laboratory
I Environmental Technology and Services
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612/778 6047

3M LIGHT WATER BRAND AQUEOUS FILM FORMING FOAM (AFFF) DISPOSAL RECOMMENDATIONS AND HAZARD EVALUATION

CONCLUSIONS:

Light Water Brand AFFF and ATC wastes are treatable in a wastewater treatment system if disposed of according to 3M recommendations. These products have low toxicity to the microorganisms in wastewater treatment systems even at concentrations much higher than those recommended by 3M. Foaming problems may develop, however, particularly when recommended discharge concentrations are exceeded.

Fluorochemical thermal decomposition products do not present a health hazard during fire fighting nor do they affect the treatability of aqueous fire fighting wastes. The major reasons for this are that during usage, the concentration of fluorochemicals in Light Water AFFF solutions is low and little fluorochemical is burned.

DISPOSAL RECOMMENDATIONS FOR AFFF (AQUEOUS FILM FORMING FOAM) AND ATC (ALCOHOL TYPE CONCENTRATE) WASTES:

3M recommends handling wastes resulting from the use of Light Water AFFF products by pretreatment in an oil/water separator. The oil fraction from the separator should be incinerated in a facility designed to accept such wastes. Disposal of the aqueous fraction from the oil/water separator or the entire waste, when pretreatment by oil/water separation is not possible, requires special considerations. A qualified individual should evaluate these wastes to determine if volatile flammable materials are present at hazardous concentrations and to review the applicability of sewer code restrictions. If volatile flammable materials in the waste present an explosion hazard, it should not be discharged to a sewer. Such wastes should be further treated to remove the hazard or they should be incinerated in a facility designed to accept such wastes.

If qualified individuals determine that the waste meets sewer codes and that flammable materials are not present in the waste at concentrations that presents a risk of explosion in the sewer, the waste may be metered into a sewer that flows to a wastewater treatment system. Meter such wastes into the sewage system at a rate sufficiently low so

Environmental Laboratory
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612/778 6047

3M LIGHT WATER BRAND AQUEOUS
FILM FORMING FOAM (AFFF)
DISPOSAL RECOMMENDATIONS AND HAZARD EVALUATION
(CON'T)

that the AFFF will not cause excessive foaming in the aeration basin of the wastewater treatment system. Appropriate discharge rates will be determined by individual circumstances and should follow applicable regulations. Since regulations vary, consult regulations or authorities before discharge. In addition, wastewater treatment plant operators should be contacted to determine the capacity of the treatment system and sewage flow rates into the system so that appropriate AFFF waste discharge rates can be determined.

For most AFFF or ATC products used at 6%, 3M recommends adjusting the discharge rate so that the product concentration in the aeration basin of the wastewater treatment system will be less than 100 mg per liter of sewage. For most products used at 3%, 3M recommends a maximum product concentration of 50 mg/L in the aeration basin. Products used at 3% require greater dilution than products used at 6% because the 3% concentrates have higher surfactant concentrations than the 6% concentrates. Product Environmental Data Sheets for products with higher surfactant concentrations may recommend somewhat greater dilution.

In some situations, metered discharge of wastes to a wastewater treatment system is impractical because the small size of the treatment system limits the discharge rate to such an extent that too much time would be required for disposal. 3M recommends two disposal alternatives in these situations: (1) transporting collected waste materials by tank trucks for metered discharge into a larger waste treatment facility, or (2) discharging the waste at a somewhat higher rate with appropriate concentrations of antifoaming agent added to the waste stream to control foaming.

Experiments conducted in the 3M Environmental Laboratory have determined that several antifoaming products are effective at controlling excessive foaming in activated sluge/AFFF mixtures for up to 3 hours. The effectiveness of antifoaming agents, however, will be determined by the specific conditions in the aeration basin in individual wastewater treatment systems. In addition, some antifoamers may become less effective at controlling excessive foaming as time passes. Therefore, foaming should be closely monitored over time and additional antifoamer should be added to the aeration basin as needed.

3M Product Environmental Data Sheet

Form 14705 - H - PWO

Environmental Laboratory
Environmental Technology and Services
935 Bush Avenue
PO Box 33331
St. Paul, MN 55133-3331
612/778 6047

3M LIGHT WATER BRAND AQUEOUS
FILM FORMING FOAM (AFFF)
DISPOSAL RECOMMENDATIONS AND HAZARD EVALUATION
(CON'T)

While this is not an endorsement, the following nine products were found to be the most effective of thirty-one antifoam products tested using activated sludge/AFFF mixtures in laboratory tests:

GE Silicones 1-800-332-3390	Antifoam Emulsion AF72 Antifoam Emulsion AF93 Antifoam Emulsion AF9020
Henkel 1-800-922-0605	Defoamer WB-209 Foammaster™ DS
Union Carbide 1-800-523-5862	SAG 2001 Organosilicone Emulsion
Wacker Silicones 1-800-248-0063	Antifoam Agent SE-36 Antifoam Agent SWS-214 Antifoam Emulsion SRE

Of these nine products, the most cost-effective were Henkel WB-209, GE Silicones AF9020, Henkel Foammaster™ DS, and Wacker Silicones SRE. The cost analysis used in that study was based on antifoam prices obtained in July, 1992. Price and transport charges may vary which could cause other products to be more cost-effective in some locations.

The antifoam concentration required to limit foaming in laboratory tests on FC-203CF solutions of various concentrations are tabulated below. The products are listed in the table in order of most to least cost-effective. The antifoam concentrations given in the table are intended to serve as estimates since the actual antifoam concentration required to suppress foaming will be determined by the specific conditions in the aeration basin. Where no data are given in the table, the antifoam agent is not recommended for suppressing foam at or above that AFFF concentration.

The antifoam concentrations in the table were obtained in laboratory tests using 3M FC-203CF, but they are the approximate antifoam concentrations required for other 3M AFFF and ATC products used at 3%.

3M Product Environmental Data Sheet

Form 14705 - H - PWO

Environmental Laboratory
| Environmental Technology and Services

935 Bush Avenue
PO Box 33331
St. Paul, MN 55133-3331
612/778 6047

3M LIGHT WATER BRAND AQUEOUS
FILM FORMING FOAM (AFFF)
DISPOSAL RECOMMENDATIONS AND HAZARD EVALUATION
(CON'T)

For 3M AFFF products used at 6% in water, the antifoam concentrations should be approximately correct for twice the AFFF concentrations given at the top of each column. This is, the antifoam concentrations would be approximately correct for 6% AFFF concentrates at 200, 600, 1000, 1200, 1400, 1600, 1800, and 2200 mg/L in the aeration basin.

The AFFF and antifoam concentrations given in the preceding paragraph and in the table below are for foam control only.. Other factors must be considered in selecting rates of discharge to a sewer. 3M recommends a case-by-case determination of the maximum concentrations of AFFF and antifoam to be discharged to a treatment system and subsequently to an aquatic environment. The maximum concentration will depend on a variety of factors, including the conditions in the individual wastewater treatment system and in the receiving watercourse, as well as the dilution factor of the treated wastewater in the receiving watercourse. These factors should be evaluated in each situation to ensure that neither the AFFF nor the antifoam will cause harm. Product Environmental Data Sheets on the particular 3M AFFF product(s) will help in this evaluation.

Determination of the approximate antifoam concentration from the table is best explained by an example. Suppose that AFFF usage waste is to be discharged at a rate that will result in a concentration of FC-203CF of 700 mg/L in the aeration basin of a wastewater treatment system. The approximate antifoam concentrations needed to control foaming at this AFFF concentration are listed in the "700" column of the table. The numbers in this column are the approximate concentrations of antifoam products needed to control foaming caused by FC-203CF at 700 mg/L. Each row gives the approximate antifoam concentration for the product listed on the left side of the table. If you intend to use Henkel Foammaster™ DS for foam control, read down the column under the heading "700" until you reach the row for Henkel Foammaster™ DS. The number in the table is "430" which means that Henkel Foammaster™ DS should be added to the aeration basin at approximately 430 mg/L to control foaming caused by FC-203CF at 700 mg/L. Another possible antifoamer for controlling foaming by FC-203CF at 700 mg/L is Wacker Silicones SE-36. Reading from the table under the "700" column at the Wacker Silicones SE-36 row gives "580" which means that to control

Environmental Laboratory
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612/778 6047

3M LIGHT WATER BRAND AQUEOUS
FILM FORMING FOAM (AFFF)
DISPOSAL RECOMMENDATIONS AND HAZARD EVALUATION
(CON'T)

foaming of FC-203CF at 700 mg/L with Wacker Silicones SE-36, you will need to add Wacker Silicones SE-36 so that its concentration is approximately 580 mg/L. As you can see from the table, Henkel WB-209, Wacker Silicones SWS-214, and Union Carbide SAG 2001 are not recommended for controlling foaming from an FC-203CF concentration of 700 mg/L. The absence of a value for these products in the "700" column indicates these three products are not recommended for controlling foam at an FC-203CF concentration of 700 mg/L.

	FC-203CF Concentration (mg/L)*							
	100	300	500	600	700	800	900	1100
Henkel WB-209	20	100	190	---	---	---	---	---
GE Silicones AF9020	20	100	190	270	430	500	740	1950
Henkel Foammaster™ DS	20	110	200	300	430	500	690	1600
Wacker Silicones SRE	20	100	190	270	400	490	---	---
Wacker Silicones SWS-214	40	170	430	---	---	---	---	---
GE Silcones AF93	20	100	190	270	430	480	530	1600
GE Silicones AF72	20	100	190	270	430	480	600	1800
Wacker Silicones SE-36	30	140	310	470	580	---	---	---
Union Carbide SAG 2001	50	220	600	---	---	---	---	---

* See text for precautions and for extrapolating these data to other 3M AFFF products.

3M Product Environmental Data Sheet

Form 14705 - H - PWO

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935 Bush Avenue
PO Box 33331
St. Paul, MN 55133-3331
612/778 6047

3M LIGHT WATER BRAND AQUEOUS
FILM FORMING FOAM (AFFF)
DISPOSAL RECOMMENDATIONS AND HAZARD EVALUATION
(CON'T)

In situations where antifoam agents are used to control excessive foaming by 3M products used at 6% in water, 3M recommends adjusting the discharge rate so that the product concentration in the aeration basin of the wastewater treatment system will be less than 1,000 mg/L of sewage. When antifoam agents are used to control foaming by 3M products used at 3%, 3M recommends a maximum AFFF concentration of 500 mg/L in the aeration basin. These maximum concentrations are based on laboratory studies that have shown that 3M AFFF products at or below these concentrations are unlikely to cause toxicity in wastewater treatment systems. The AFFF and antifoam concentrations in the table that are greater than these maximum recommended concentrations are provided to assist customers in dealing with emergency foaming situations or where elevated concentrations are appropriate because of individual circumstances. In all cases, applicable local regulations and the antifoam Material Safety Data Sheet (MSDS) should be consulted before use.

At 3M's own wastewater treatment facilities, foaming caused by Light Water AFFF discharges has been controlled by spraying a dilution of Wacker Silicones Antifoam Emulsion SWS-214 over the aeration basin.

This dilution is prepared by mixing one part of SWS-214 in twenty parts of water. The antifoam dilution is sprayed over the aeration basin surface until the desired level of foam control is obtained. This procedure could be used as an alternative to adding the antifoam directly to the AFFF containing waste stream.

REASONS FOR 3M DISPOSAL RECOMMENDATIONS:

The primary reason for recommending discharge to a sewer is that 3M AFFF wastes are treatable in a biological wastewater treatment system. Light Water AFFF usage wastes are approximately 99% water and therefore have very low concentrations of organic compounds. The dilute nature of the waste makes alternative disposal methods, such as incineration, carbon adsorption, ultrafiltration, or reverse osmosis, both difficult and costly. Moreover, the major components of 3M AFFF usage wastes are a biodegradable solvent, Butyl Carbitol™ (<1%), and a mixture of biodegradable and partially biodegradable surfactants (<0.3%).

3M Product Environmental Data Sheet

Form 14705 - H - PWO

Environmental Laboratory
I Environmental Technology and Services
935 Bush Avenue
PO Box 33331
St. Paul, MN 55133-3331
612/778 6047

Chemicals are generally considered biodegradable when the ratio of their 20-day Biochemical Oxygen Demand (BOD_{20}) to their Chemical Oxygen Demand (COD) is greater than 0.6. This is the pass level for respirometric ready-biodegradability tests established by the Organization for Economic Cooperation and Development (OECD). The BOD_{20}/COD for Butyl Carbitol was found to be 0.85. There are several biodegradable surfactants in these products and their BOD_{20}/COD ratios were found to lie between 0.74 and 0.94. There are also surfactants in these products with BOD_{20}/COD ratios less than 0.6. This includes the fluorochemical surfactants and some of the hydrocarbon surfactants. The hydrocarbon surfactants that do not meet this BOD_{20}/COD criteria will likely fully biodegrade given more time. Some fluorochemical surfactants may have both hydrocarbon and fluorochemical portions. The fluorochemical portions of these surfactants are not known to biodegrade, but the hydrocarbon portions are likely to be biodegraded to some degree in most wastewater treatment systems and, like the fully hydrocarbon surfactants, eventually completely biodegrade. Possible fates of the nondegradable materials in wastewater treatment systems include sorption onto the microbial solids or passage out of the system with the treated wastewater. In any event, their concentration will be very low. Nonbiodegradable fluorochemical materials are used in AFFF products because they are required to make the products work. All effective AFFF products on the market today (and all fluoroprotein products as well) contain fluorochemical surfactants. Finally, laboratory tests on both the individual product components and the product concentrates have determined the low toxicity of these materials to activated sludge bacteria, so discharge to ordinary wastewater treatment systems is reasonable.

Laboratory studies have shown that foaming, not toxicity, is usually the cause of problems from improper disposal of AFFF wastes to wastewater treatment systems. In laboratory studies, wastewater containing FC-600 Light Water AFFF at 1,000 mg/L was treated successfully without toxicity. In that lab study, the foam was physically broken down and returned to the treatment system along with activated sludge solids that came out because of foaming. With these modifications to the normal treatment process, the quality of the treated effluent from the laboratory scale system was not adversely affected. Treatment at this concentration is not recommended, however, because of excessive foaming.

Environmental Laboratory
| Environmental Technology and Services
935 Bush Avenue
PO Box 33331
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612/778 6047

3M LIGHT WATER BRAND AQUEOUS
FILM FORMING FOAM (AFFF)
DISPOSAL RECOMMENDATIONS AND HAZARD EVALUATION
(CON'T)

Light Water AFFF wastes resulting from testing the operability of a fire fighting system, such as that installed in a hanger facility, normally don't contain much fuel or oil. On the other hand, wastes from fire fighting training facilities where hydrocarbon fires are extinguished may contain suspended oil. If oil is present, it should be separated from the waste before discharging the waste to a sewer as described above. If oil is emulsified in the waste, it may be difficult to separate but many oils can biodegrade. Furthermore, emulsified oils are more likely to biodegrade in a wastewater treatment system than are nonemulsified oils.

3M recommends metered discharge of Light Water AFFF wastes to flowing sewers because discharge to an intermittently flowing sewer could cause waste to collect and to be flushed to aeration basins at higher than recommended concentrations. Uncontrolled sewer discharge rates also could result in foam backing out of sewer drains.

THERMAL DECOMPOSITION FROM LIGHT WATER AFFF USAGE:

Thermal decomposition products resulting from Light Water AFFF usage present an insignificant hazard. Considerable confusion was caused by a precautionary statement formerly used on Light Water AFFF Material Safety Data Sheets (MSDSs). That statement was frequently misinterpreted as meaning that thermal decomposition products from usage concentration levels could cause a health hazard. The precaution once simply stated: "Thermal decomposition may produce toxic materials, including HF." This statement has now been modified to include: "Decomposition of usage concentrations does not present a hazard."

The former MSDS precaution for Light Water AFFF products is still used on the MSDSs for other 3M products containing fluorochemicals. The statement is used because it is well known that most fluorochemical materials, including such commonly used items as polytetrafluoroethylene (PTFE) coated frying pans, utensils, etc., can liberate toxic fumes including HF or perfluorobutylenes under combustion or pyrolysis conditions. However, this will occur only if very high temperature conditions exist (>300C).

3M Product Environmental Data Sheet

Form 14705 - H - PWO

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Environmental Technology and Services
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612/778 6047

3M LIGHT WATER BRAND AQUEOUS
FILM FORMING FOAM (AFFF)
DISPOSAL RECOMMENDATIONS AND HAZARD EVALUATION
(CON'T)

Furthermore, formation of hazardous concentrations of thermal by-products is more likely in fluorocarbon containing products with high fluorine content (65 or 70%), but the fluorochemical content of 3M AFFF products is very low. For example, FC-206CF Light Water AFFF concentrate contains only about 1.1% fluorine, and when diluted to the usage concentration, it contains only about 0.06% fluorine. Thus, from a combustion or pyrolysis product hazard perspective, PTFE, which is widely known as a nontoxic, inert material, would be far more hazardous.

There are other reasons that make the production of hazardous concentrations of thermal degradation products during fire fighting with Light Water AFFF very unlikely. Most importantly, little of the fluorochemical would burn or thermally decompose. The reasons for this are that the product rapidly covers and extinguishes the fire, and the high percentage of water absorbs considerable heat, thereby cooling and limiting the decomposition of the dissolved fluorochemical.

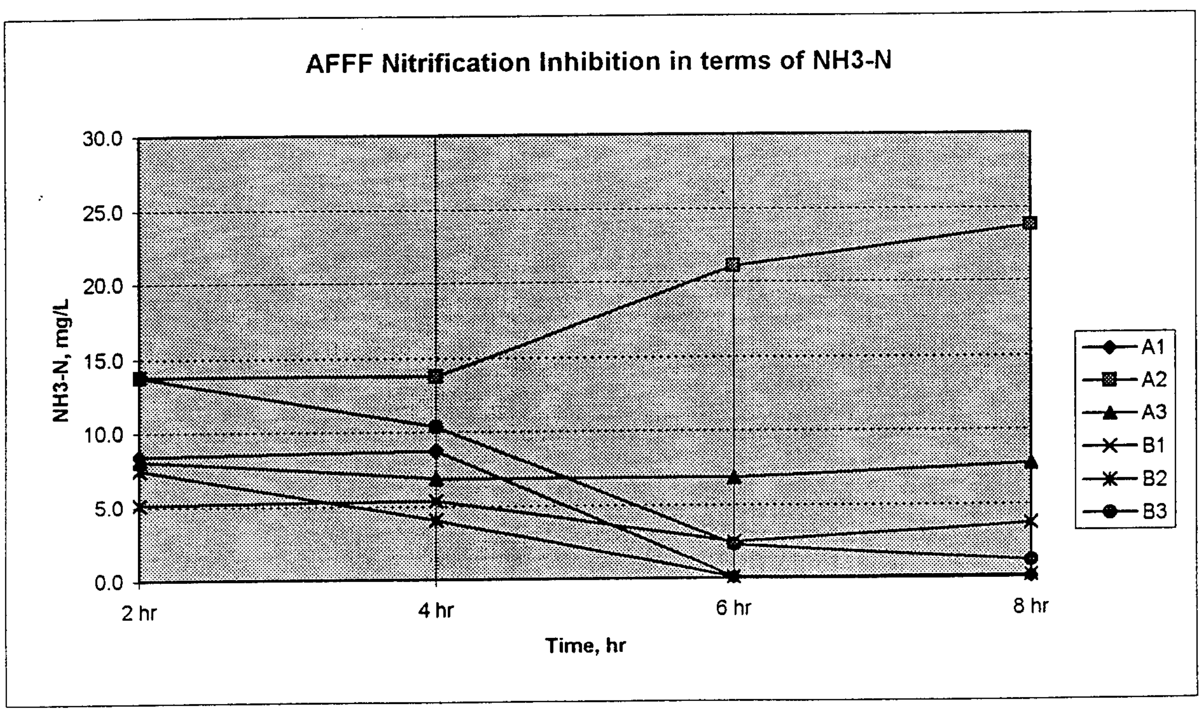
The 3M Industrial Hygiene Department conducted a test to confirm the lack of hazard from fluorochemical combustion when Light Water AFFF is used in fire fighting. The test was designed to simulate a "worst case" situation by maximizing the chance of fluorochemical combustion. The test burned a 2-3 inch layer of FC-203CE Light Water AFFF foam in a 10 square foot pan of gasoline inside a 20 by 20 foot wide and 15 foot high open topped concrete building. To cause the fluorochemical in the Light Water AFFF product to burn, the test operator had to stir vigorously the foam and gasoline, an atypical procedure. Stirring broke the foam barrier and allowed combustion that would normally have been extinguished by the foam. Even under this worst case situation, two HF measurements taken above and near this fire were only 0.23 and 0.16 parts per million (ppm). While not directly applicable to this situation, these measurements were below the Threshold Limit Value for HF of 3 ppm, a concentration judge not to present a health hazard for nearly all persons.

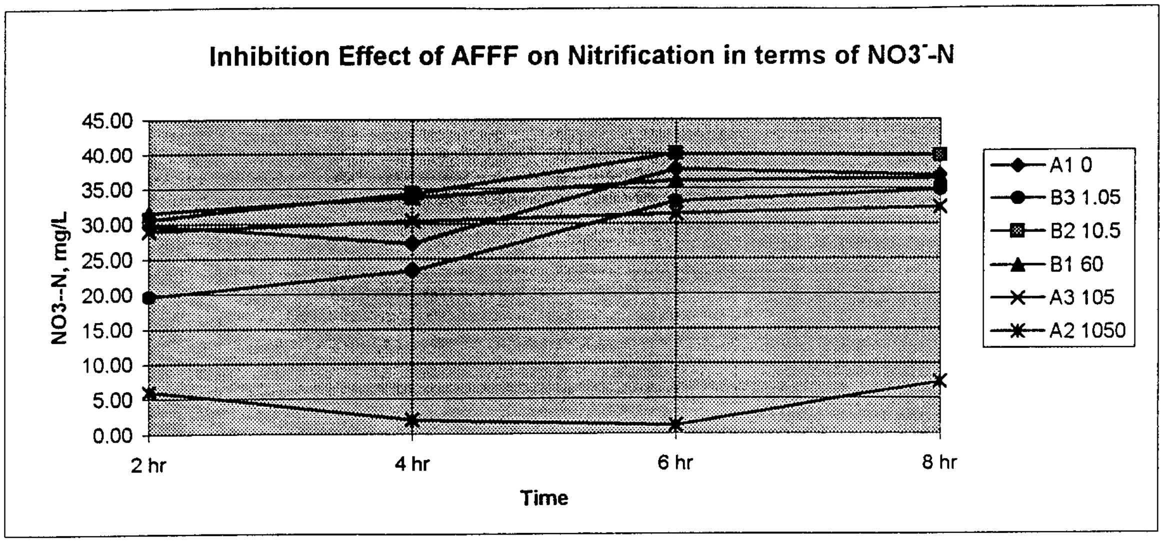
Thus, fluorochemical decomposition products from Light Water AFFF present an insignificant risk when compared to the many other hazardous decomposition products resulting from a fire. Light Water AFFF products certainly play a much more significant role in reducing the toxicity hazards of fire situations by rapidly cooling and extinguishing a fire and by covering and preventing the volatilization of other potentially toxic materials.

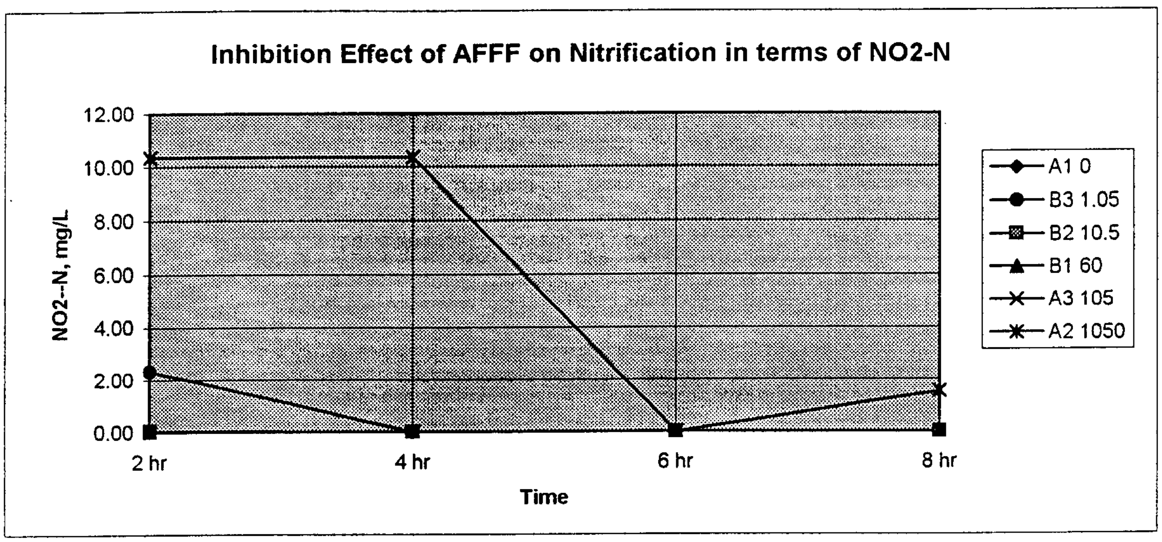
Appendix II

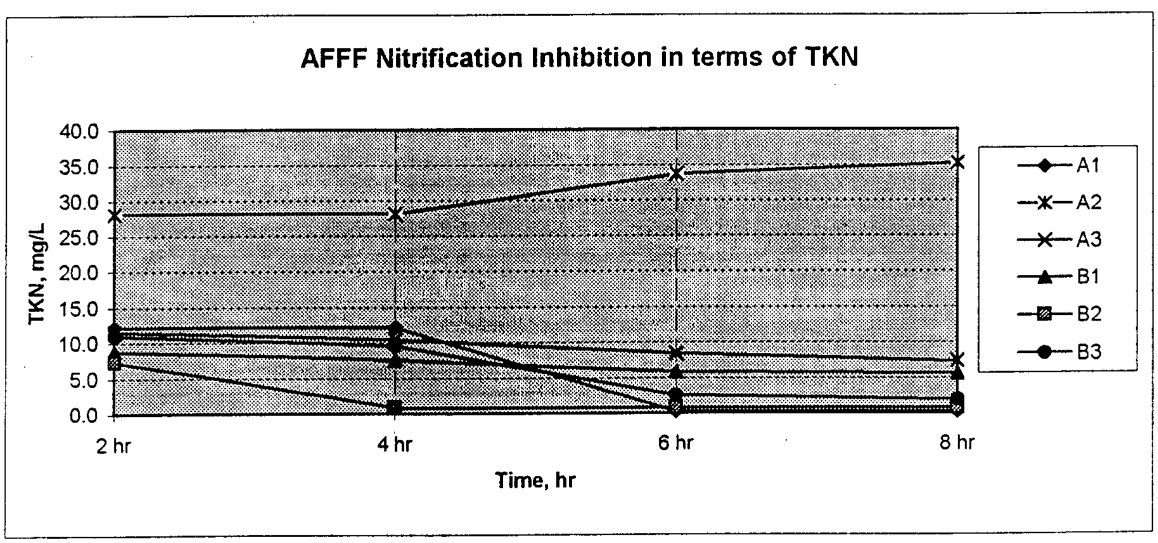
Range-Finding Test Results

Reactor	AFFF (ppm)	Time	Stage	pH	NH3-N	TKN
A1	0	2 hr	End of Feeding	7.9	8.4	12.2
		4 hr	End of Anaerobic	7.9	8.7	12.2
		6 hr	End of Aerobic	8.0	0.1	0.3
		8 hr	Supernatent	7.8	0.1	0.3
B3	1.05	2 hr	End of Feeding	7.8	13.7	11.0
		4 hr	End of Anaerobic	8.1	10.3	9.6
		6 hr	End of Aerobic	7.9	2.3	2.6
		8 hr	Supernatent	8.0	1.2	2.0
B2	10.5	2 hr	End of Feeding	7.8	7.5	7.3
		4 hr	End of Anaerobic	7.9	4.0	0.9
		6 hr	End of Aerobic	7.9	0.1	0.8
		8 hr	Supernatent	7.9	0.2	0.8
B1	60	2 hr	End of Feeding	7.9	5.2	8.8
		4 hr	End of Anaerobic	7.9	5.4	7.7
		6 hr	End of Aerobic	7.8	2.5	5.9
		8 hr	Supernatent	7.8	3.7	5.6
A3	105	2 hr	End of Feeding	7.8	8.1	11.5
		4 hr	End of Anaerobic	8.0	6.9	10.5
		6 hr	End of Aerobic	8.1	6.8	8.4
		8 hr	Supernatent	8.0	7.7	7.3
A2	1050	2 hr	End of Feeding	7.7	13.7	28.2
		4 hr	End of Anaerobic	7.8	13.7	28.2
		6 hr	End of Aerobic	7.8	21.1	33.7
		8 hr	Supernatent	7.9	23.8	35.2



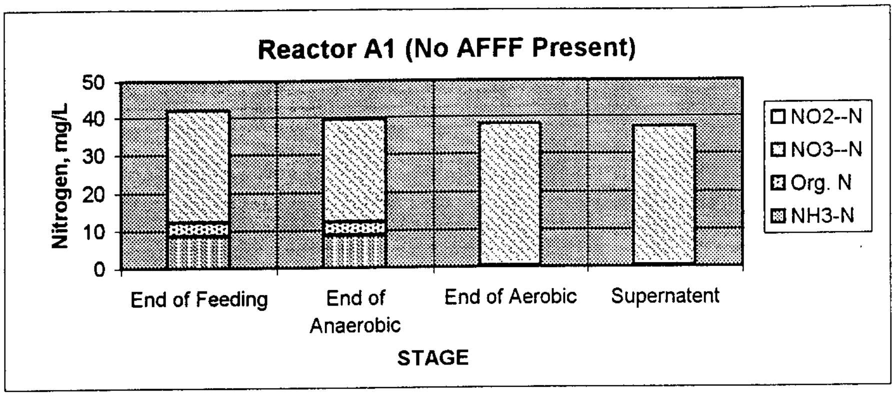

Inhibition Effect of AFFF on Nitrification in terms of NO3⁻-N
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
NO3--N, mg/L
2 hr
4 hr
6 hr
8 hr
Time
A1 0
B3 1.05
B2 10.5
B1 60
A3 105
A2 1050

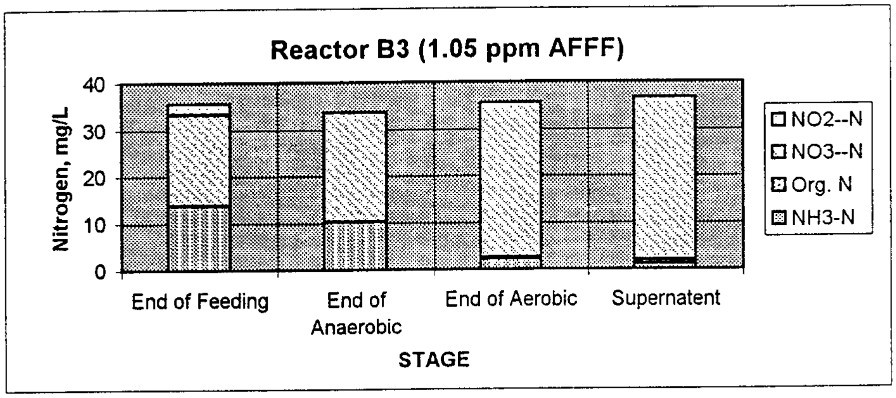

Inhibition Effect of AFFF on Nitrification in terms of NO2-N
12.00
10.00
8.00
6.00
4.00
2.00
0.00
NO2--N, mg/L
2 hr
4 hr
6 hr
8 hr
Time
A1 0
B3 1.05
B2 10.5
B1 60
A3 105
A2 1050

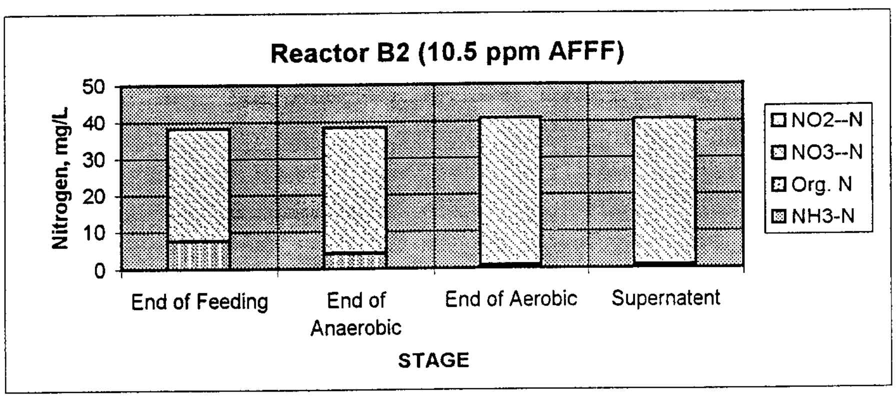

AFFF Nitrification Inhibition in terms of TKN
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
TKN, mg/L
2 hr
4 hr
6 hr
8 hr
Time, hr
A1
A2
A3
B1
B2
B3

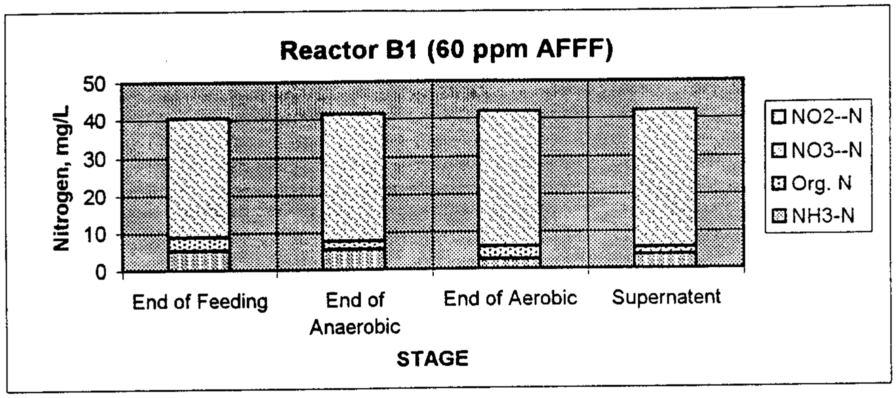
Date of Test: 1-4-97 Inhibition Reactors / Nitrogen Mass Balance AFFF Range Finding

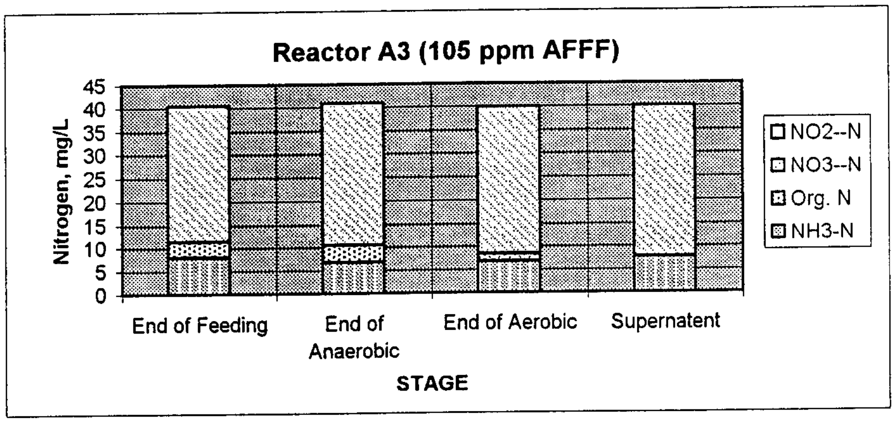
					Nitrogen Concentration, mg/L					
Reactor	AFFF (ppm)	Stage	Time	pH	TKN	NH3-N	Org. N	NO3--N	NO2--N	Total
A1	0	End of Feeding	2 hr	7.9	12.15	8.41	3.74	29.72	0.00	41.87
(Control)		End of Anaerobic	4 hr	7.9	12.15	8.69	3.46	27.21	0.00	39.36
		End of Aerobic	6 hr	8.0	0.28	0.10	0.18	37.79	0.00	38.07
		Supernatent	8 hr	7.8	0.28	0.10	0.18	36.87	0.00	37.15
B3	1.05	End of Feeding	2 hr	7.8	10.96	13.72	0.00	19.65	2.32	35.69
		End of Anaerobic	4 hr	8.1	9.58	10.32	0.00	23.40	0.00	33.72
		End of Aerobic	6 hr	7.9	2.61	2.30	0.31	33.12	0.00	35.73
		Supernatent	8 hr	8.0	1.99	1.16	0.83	34.80	0.00	36.79
B2	10.5	End of Feeding	2 hr	7.8	7.32	7.45	0.00	30.64	0.04	38.13
		End of Anaerobic	4 hr	7.9	0.89	4.04	0.00	34.26	0.00	38.30
		End of Aerobic	6 hr	7.9	0.81	0.09	0.72	40.03	0.00	40.84
		Supernatent	8 hr	7.9	0.81	0.15	0.66	39.74	0.00	40.55
B1	60	End of Feeding	2 hr	7.9	8.76	5.16	3.60	31.57	0	40.33
		End of Anaerobic	4 hr	7.9	7.65	5.37	2.28	33.72	0.00	41.37
		End of Aerobic	6 hr	7.8	5.85	2.49	3.36	36.07	0.00	41.92
		Supernatent	8 hr	7.8	5.59	3.73	1.86	36.50	0.00	42.09
A3	105	End of Feeding	2 hr	7.8	11.47	8.08	3.39	28.91	0	40.38
		End of Anaerobic	4 hr	8.0	10.48	6.86	3.62	30.32	0.00	40.80
		End of Aerobic	6 hr	8.1	8.37	6.83	1.54	31.40	0.00	39.77
		Supernatent	8 hr	8.0	7.32	7.70	0.00	32.26	0.00	39.96
A2	1050	End of Feeding	2 hr	7.7	28.15	13.72	14.43	5.99	10.35	44.49
		End of Anaerobic	4 hr	7.8	28.15	13.72	14.43	2.02	10.37	40.54
		End of Aerobic	6 hr	7.8	33.68	21.10	12.58	1.20	0.00	34.88
		Supernatent	8 hr	7.9	35.23	23.81	11.42	7.40	1.54	44.17

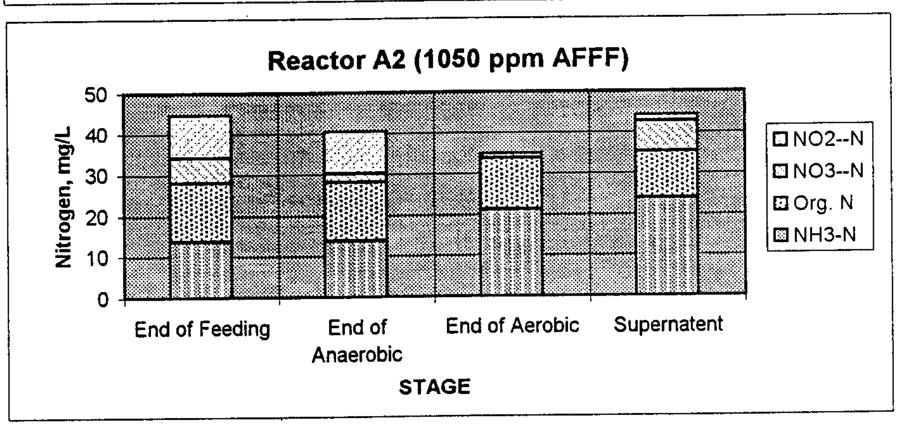

Reactor A1 (No AFFF Present)
Nitrogen, mg/L
50
40
30
20
10
0
End of Feeding
End of Anaerobic
End of Aerobic
Supernatent
STAGE
NO2--N
NO3--N
Org. N
NH3-N


Reactor B3 (1.05 ppm AFFF)
Nitrogen, mg/L
40
30
20
10
0
End of Feeding
End of Anaerobic
End of Aerobic
Supernatent
STAGE
NO2--N
NO3--N
Org. N
NH3-N


Reactor B2 (10.5 ppm AFFF)
Nitrogen, mg/L
50
40
30
20
10
0
End of Feeding
End of Anaerobic
End of Aerobic
Supernatent
STAGE
NO2--N
NO3--N
Org. N
NH3-N

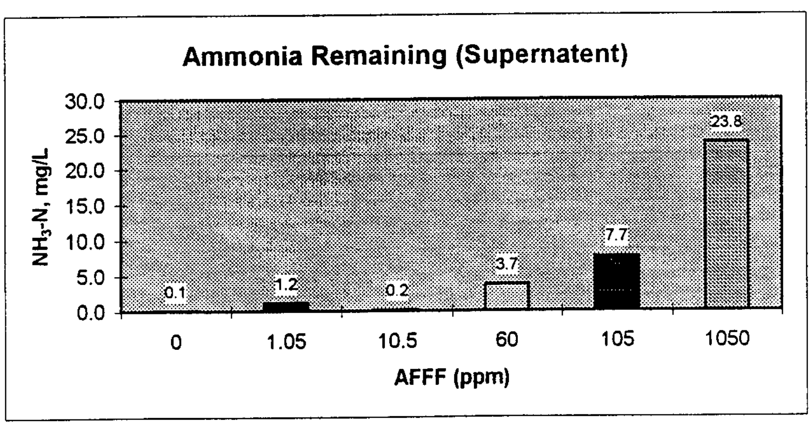

Reactor B1 (60 ppm AFFF)
Nitrogen, mg/L
50
40
30
20
10
0
End of Feeding
End of Anaerobic
End of Aerobic
Supernatent
STAGE
NO2--N
NO3--N
Org. N
NH3-N

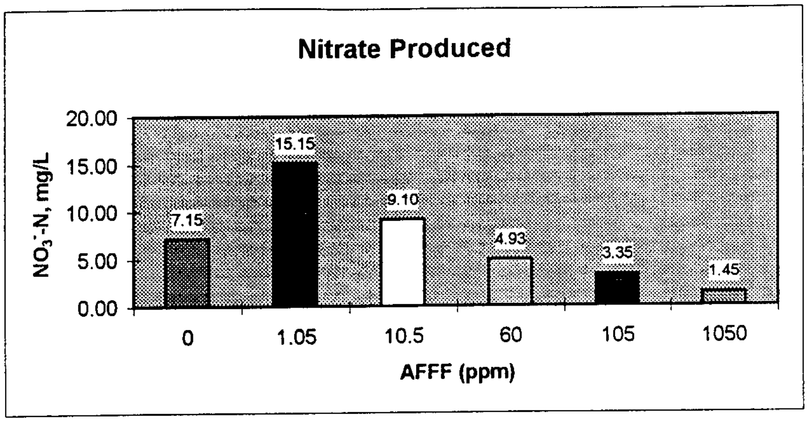

Reactor A3 (105 ppm AFFF)
Nitrogen, mg/L
45
40
35
30
25
20
15
10
5
0
End of Feeding
End of Anaerobic
End of Aerobic
Supernatent
STAGE
NO2--N
NO3--N
Org. N
NH3-N

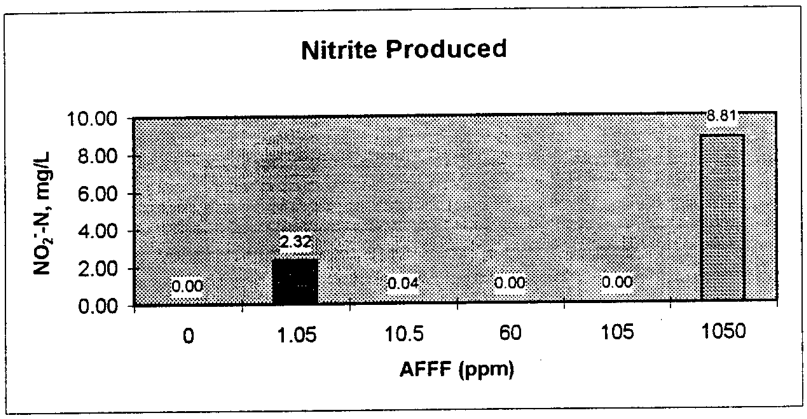

Reactor A2 (1050 ppm AFFF)
Nitrogen, mg/L
50
40
30
20
10
0
End of Feeding
End of Anaerobic
End of Aerobic
Supernatent
STAGE
NO2--N
NO3--N
Org. N
NH3-N

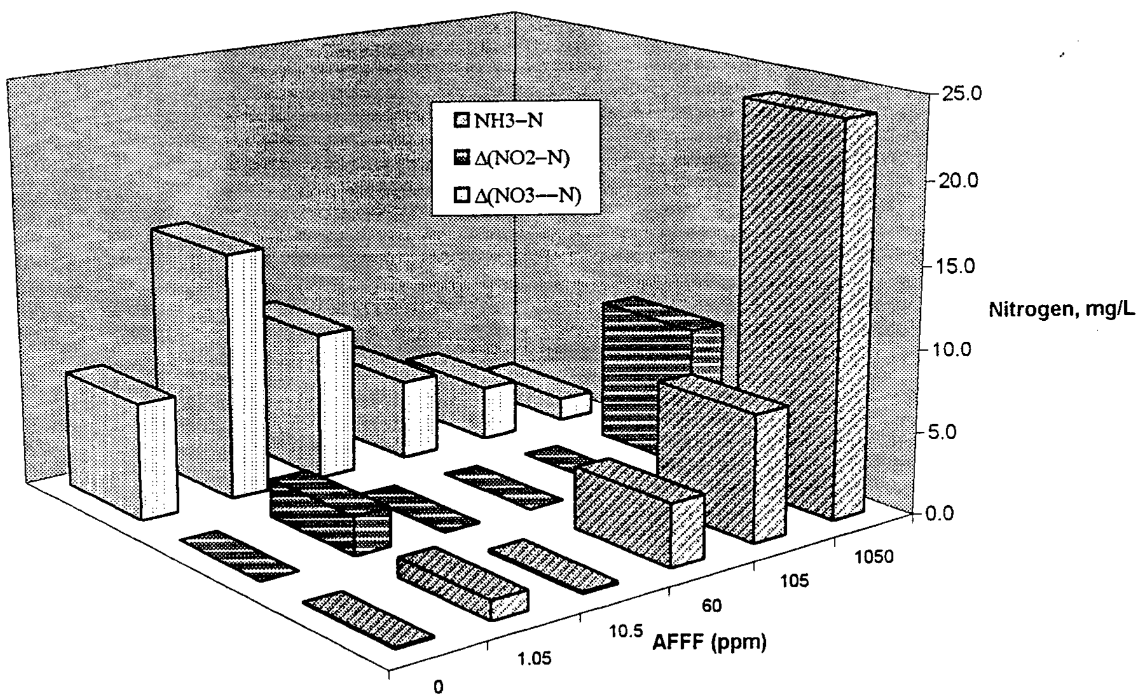
Date of Test: 1-4-97 Inhibition Reactors / NO3- & NO2 Produced AFFF Range Finding

			Nitrogen Concentration, mg/L				
Reactor	AFFF ppm	Stage	NH3-N	NO3--N	NO2--N	$\Delta(NO_3^-\text{-}N)$	$\Delta(NO_2\text{-}N)$
A1	0	End of Feeding	8.4	29.7	0.00		
(Control)		End of Anaerobic	8.7	27.2	0.00		
		End of Aerobic	0.1	37.8	0.00		
		Supernatent	0.1	36.9	0.00	7.15	0.00
B3	1.05	End of Feeding	13.7	19.7	2.32		
		End of Anaerobic	10.3	23.4	0.00		
		End of Aerobic	2.3	33.1	0.00		
		Supernatent	1.2	34.8	0.00	15.15	2.32
B2	10.5	End of Feeding	7.5	30.6	0.04		
		End of Anaerobic	4.0	34.3	0.00		
		End of Aerobic	0.1	40.0	0.00		
		Supernatent	0.2	39.7	0.00	9.10	0.04
B1	60	End of Feeding	5.2	31.6	0.00		
		End of Anaerobic	5.4	33.7	0.00		
		End of Aerobic	2.5	36.1	0.00		
		Supernatent	3.7	36.5	0.00	4.93	0.00
A3	105	End of Feeding	8.1	28.9	0.00		
		End of Anaerobic	6.9	30.3	0.00		
		End of Aerobic	6.8	31.4	0.00		
		Supernatent	7.7	32.3	0.00	3.35	0.00
A2	1050	End of Feeding	13.7	6.0	10.35		
		End of Anaerobic	13.7	2.0	10.37		
		End of Aerobic	21.1	1.2	0.00		
		Supernatent	23.8	7.4	1.54	1.45	8.81

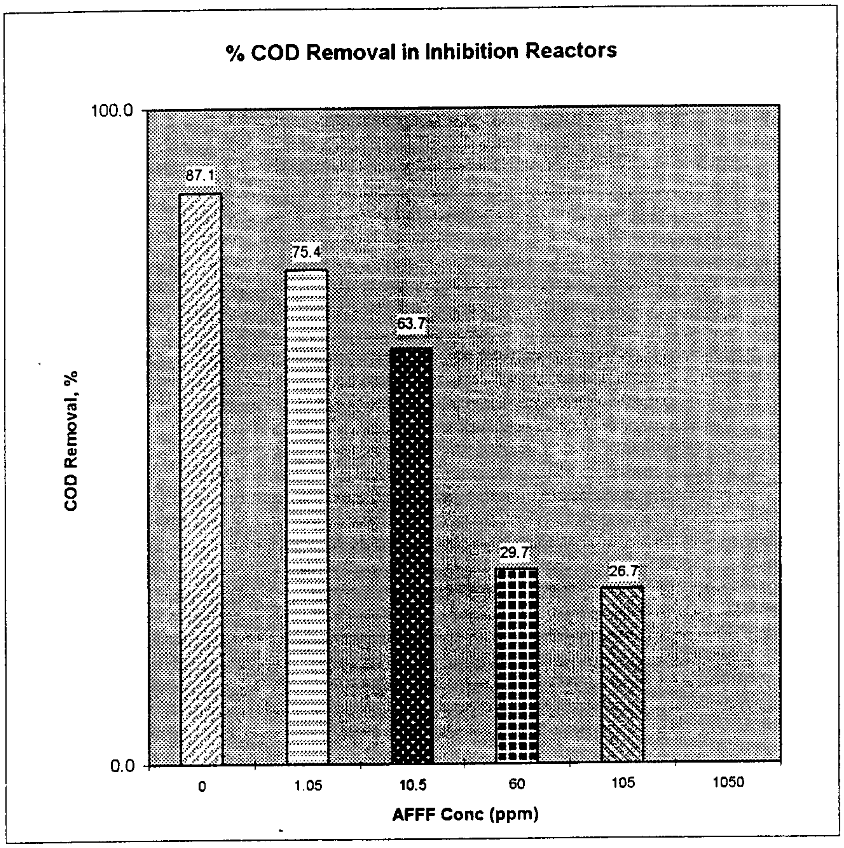



Nitrate Produced
20.00
15.00
10.00
5.00
0.00
NO_3^--N, mg/L
7.15
15.15
9.10
4.93
3.35
1.45
0
1.05
10.5
60
105
1050
AFFF (ppm)

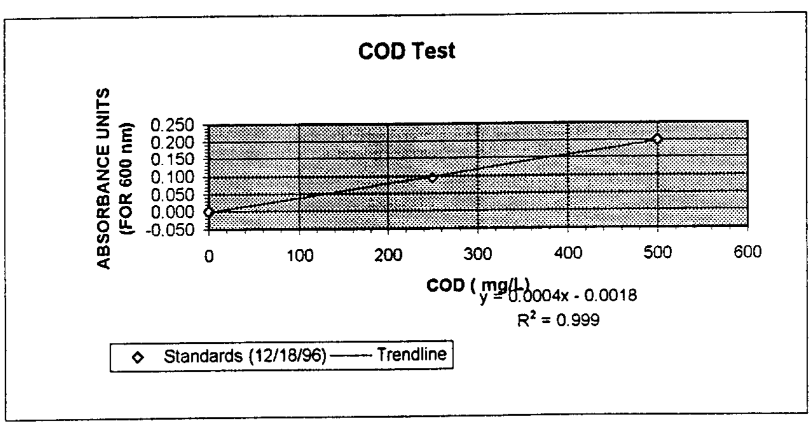

Nitrite Produced
10.00
8.00
6.00
4.00
2.00
0.00
NO_2^--N, mg/L
0.00
2.32
0.04
0.00
0.00
8.81
0
1.05
10.5
60
105
1050
AFFF (ppm)


NH3–N
Δ(NO2–N)
Δ(NO3—N)
25.0
20.0
15.0
10.0
5.0
0.0
Nitrogen, mg/L
0
1.05
10.5
60
105
1050
AFFF (ppm)

	Initial COD =		171	181	267	718	1128	9738
		Feedstock	Inhibition Reactors Samples w/ AFFF					
Date	AFFF (ppm)	N/A	0	1.05	10.5	60	105	1050
1/4/97	ABS	0.188	0.007	0.016	0.037	0.2	0.329	1.59
	COD, mg/L	474.5	22.0	44.5	97.0	504.5	827.0	3979.5
	COD Rem%		87.1	75.4	63.7	29.7	26.7	



Date	Sample	ABS	COD, mg/L
4-Jan	Blk	0.000	0
	STD1	0.094	250
	STD2	0.199	500



Spike Analysis Data for the AFFF Study done

intercept	0.88716186	-0.13122725	0.92516891	1.54177913
slope	3.84802E-08	2.3776E-08	1.68343E-08	5.1332E-08

	CONC. mg/l	CL	CONC. mg/l	NO_2	CONC. mg/l	NO_3	CONC. mg/l	PO_4
STD1	0	1311444	0	0	0	0	0	0
STD2	100	2555862514	10	423651157	10	503164439	10	148630845
STD3	200	5142039567	20	861832209	20	1083516445	20	329666451
STD4	300	7800988174	40	1680786603	40	2351671498	40	765223744
SPIKE1	376.27	9755154263	94.28	3970852317	85.97	5051736072	133.806395	2576631731
SPIKE2	475.59	12336320933	100.91	4249825280	95.32	5607335802	144.210548	2779313838
SPIKE3	573.36	14877000756	116.56	4908163142	118.66	6993471939	173.677051	3353347376
Actual1	406.25		104.48		79.93		121.87	
Actual2	500		113.85		89.31		131.25	
Actual3	593.75		132.6		108.06		150	

SUMMARY OUTPUT
CL

Regression Statistics	
Multiple R	0.999958397
R Square	0.999916795
Adjusted R S	0.999875193
Standard Erro	1.442262776
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	49995.8398	49995.8398	24035.0527	4.16033E-05
Residual	2	4.16024383	2.08012191		
Total	3	50000			

	Coefficients	*tandard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	0.88716186	1.20213253	0.73799006	0.53736525	-4.28520056	6.05952428	-4.2852006	6.059524
X Variable 1	3.84802E-08	2.4821E-10	155.032425	4.1603E-05	3.74123E-08	3.9548E-08	3.7412E-08	3.95E-08

SUMMARY OUTPUT
NO_2

Regression Statistics	
Multiple R	0.999898
R Square	0.999796
Adjusted R	0.999694
Standard E	0.298774
Observatio	4

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	1	874.8215	874.8215	9800.199	0.000102
Residual	2	0.178531	0.089266		
Total	3	875			

	Coefficients	*andard Erro*	*t Stat*	*P-value*	*ower 95%*	*pper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-0.13123	0.232457	-0.56452	0.629268	-1.13141	0.868955	-1.13141	0.868955
X Variable	2.38E-08	2.4E-10	98.99596	0.000102	2.27E-08	2.48E-08	2.27E-08	2.48E-08

SUMMARY OUTPUT
NO_3

Regression Statistics	
Multiple R	0.998752
R Square	0.997506
Adjusted R	0.99626
Standard E	1.044484
Observatio	4

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	1	872.8181	872.8181	800.0548	0.001248
Residual	2	2.181896	1.090948		
Total	3	875			

	Coefficients	*andard Erro*	*t Stat*	*P-value*	*ower 95%*	*pper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	0.925169	0.784933	1.17866	0.359768	-2.45213	4.302465	-2.45213	4.302465
X Variable	1.68E-08	5.95E-10	28.28524	0.001248	1.43E-08	1.94E-08	1.43E-08	1.94E-08

SUMMARY OUTPUT
PO_4

Regression Statistics	
Multiple R	0.996509
R Square	0.99303
Adjusted R	0.989545
Standard E	1.746217
Observatio	4

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	1	868.9015	868.9015	284.9537	0.003491
Residual	2	6.098544	3.049272		
Total	3	875			

	Coefficients	*andard Erro*	*t Stat*	*P-value*	*ower 95%*	*pper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	1.541779	1.286866	1.198088	0.353603	-3.99516	7.07872	-3.99516	7.07872
X Variable	5.13E-08	3.04E-09	16.88057	0.003491	3.82E-08	6.44E-08	3.82E-08	6.44E-08

Appendix III

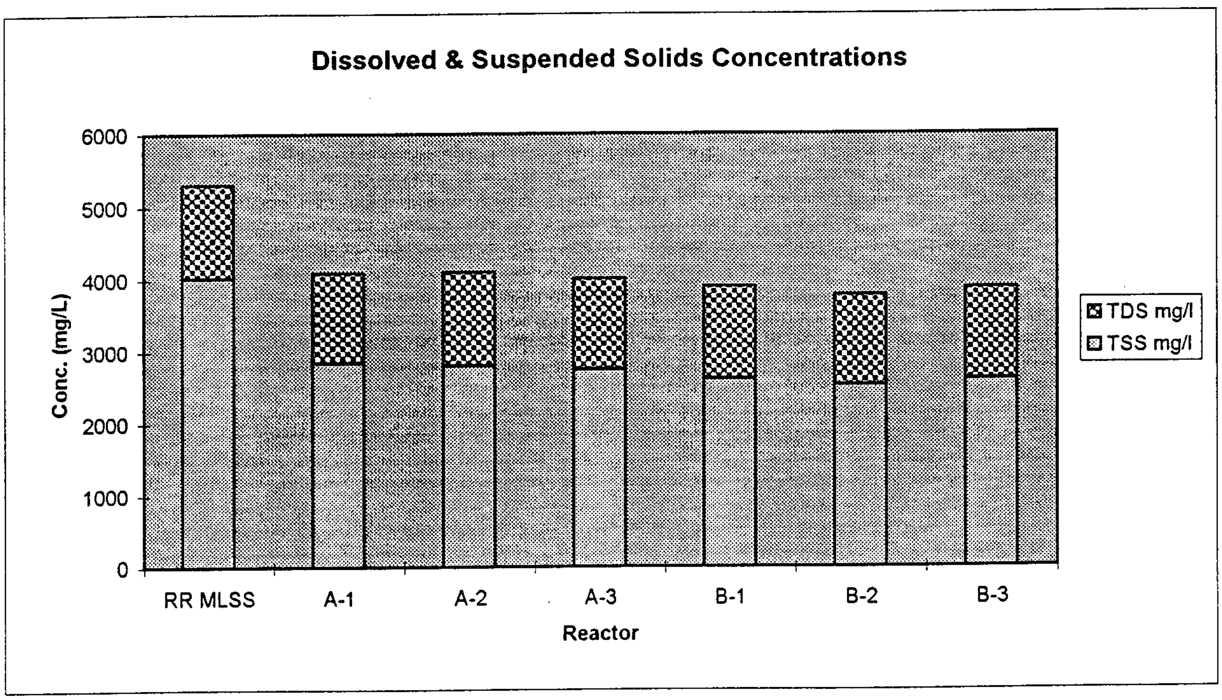
Inhibition Test Results at 10 ppm AFFF

Date of Test: 3-11-97

AFFF Conc. = 10 ppm

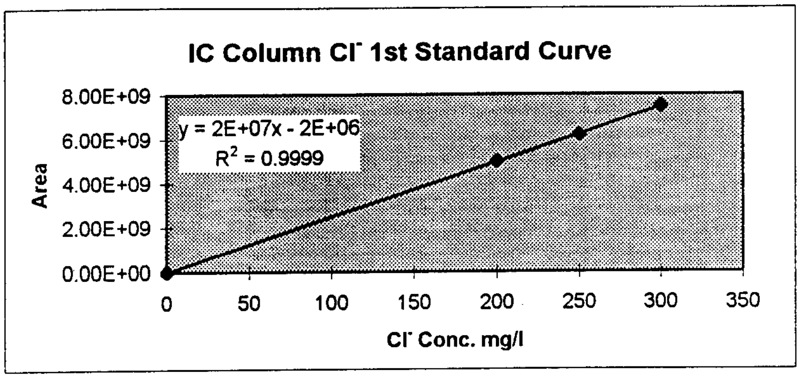
Solids Concentrations

		RR MLSS	A-1	A-2	A-3	B-1	B-2	B-3
			0 ppm AFFF	0 ppm AFFF	0 ppm AFFF	10 ppm AFFF	10 ppm AFFF	10 ppm AFFF
TSS	Empty wt. (gm)	1.0959	1.0863	1.0888	1.0924	1.1012	1.0951	1.0861
	wt.after heat (gm)	1.1964	1.1290	1.1309	1.1336	1.1404	1.1330	1.1251
	SampleVol. (mL)	25	15	15	15	15	15	15
	TSS mg/l	4020	2847	2807	2747	2613	2527	2600
TVS	Initial Weight	1.1964	1.1290	1.1309	1.1336	1.1404	1.1330	1.1251
	wt after 550oC	1.1098	1.0905	1.0926	1.0912	1.1045	1.0980	1.0896
	SampleVol. (mL)	25	15	15	15	15	15	15
	TVS mg/l	3464	2567	2553	2827	2393	2333	2367
TDS	Empty wt. (gm)	1.0032	0.9961	1.0235	1.0187	1.0185	1.0283	1.0203
	wt.after heat (gm)	1.0354	1.0148	1.0430	1.0376	1.0378	1.0473	1.0396
	SampleVol. (mL)	25	15	15	15	15	15	15
	TDS mg/l	1288	1247	1300	1260	1287	1267	1287
TS	Empty wt. (gm)	1.0053	1.0057	1.0122	1.0040	0.9967	0.9986	1.0009
	wt.after heat (gm)	1.1389	1.0680	1.0739	1.0656	1.0553	1.0554	1.0609
	SampleVol. (mL)	25	15	15	15	15	15	15
	TS mg/l	5344	4153	4113	4107	3907	3787	4000
Σ(TSS+TDS)	TS mg/l	5308	4093	4107	4007	3900	3793	3887

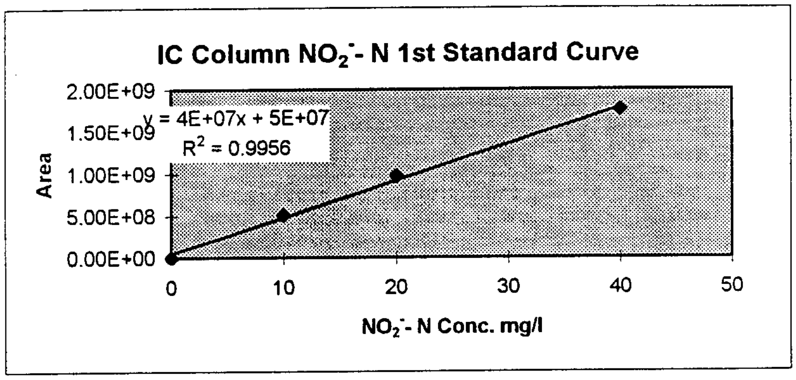


Date of Test: 3-11-97 Standards & Data AFFF Conc. = 10 ppm

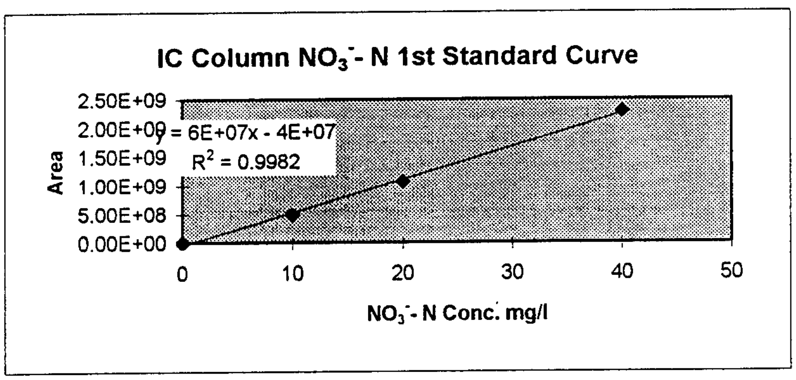
Reactor	AFFF (ppm)	Stage	Time	NH3-N (mg/L)	TKN (mg/L)
		Feedstock		10.61	323.70
		RR Decant		0.22	8.80
A1	0	End of Feeding	2 hr	0.10	15.96
		End of Anaerobic	4 hr	0.72	21.86
		End of Aerobic	6 hr	0.09	9.44
		End of Settling	8 hr	0.09	15.41
A2	0	End of Feeding	2 hr	0.14	7.39
		End of Anaerobic	4 hr	0.85	17.72
		End of Aerobic	6 hr	0.05	10.86
		End of Settling	8 hr	0.09	20.39
A3	0	End of Feeding	2 hr	0.20	10.48
		End of Anaerobic	4 hr	0.56	17.11
		End of Aerobic	6 hr	0.05	18.35
		End of Settling	8 hr	0.11	27.93
B1	10	End of Feeding	2 hr	1.05	17.11
		End of Anaerobic	4 hr	1.49	21.11
		End of Aerobic	6 hr	0.10	19.69
		End of Settling	8 hr	0.08	34.46
B2	10	End of Feeding	2 hr	0.62	17.11
		End of Anaerobic	4 hr	0.85	18.35
		End of Aerobic	6 hr	0.13	24.29
		End of Settling	8 hr	0.11	29.96
B3	10	End of Feeding	2 hr	0.92	23.45
		End of Anaerobic	4 hr	0.95	19.69
		End of Aerobic	6 hr	0.15	27.93
		End of Settling	8 hr	0.12	29.96



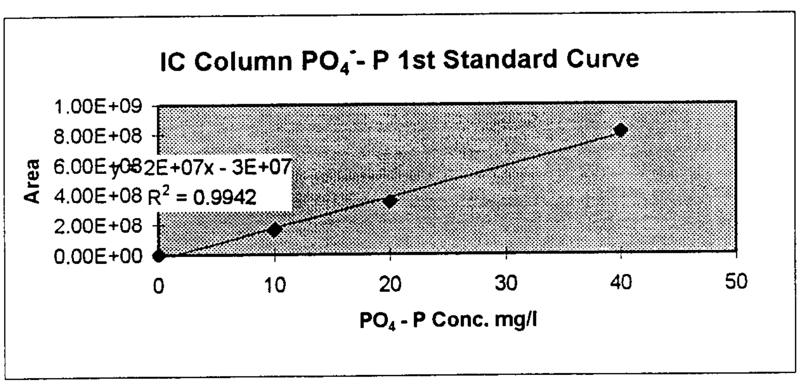
$m =$ 24896637
$i =$ -1610249



$m =$ 43624178
$i =$ 48769727



$m =$ 57740459
$i =$ -4.4E+07



$m =$ 20519441
$i =$ -2.6E+07

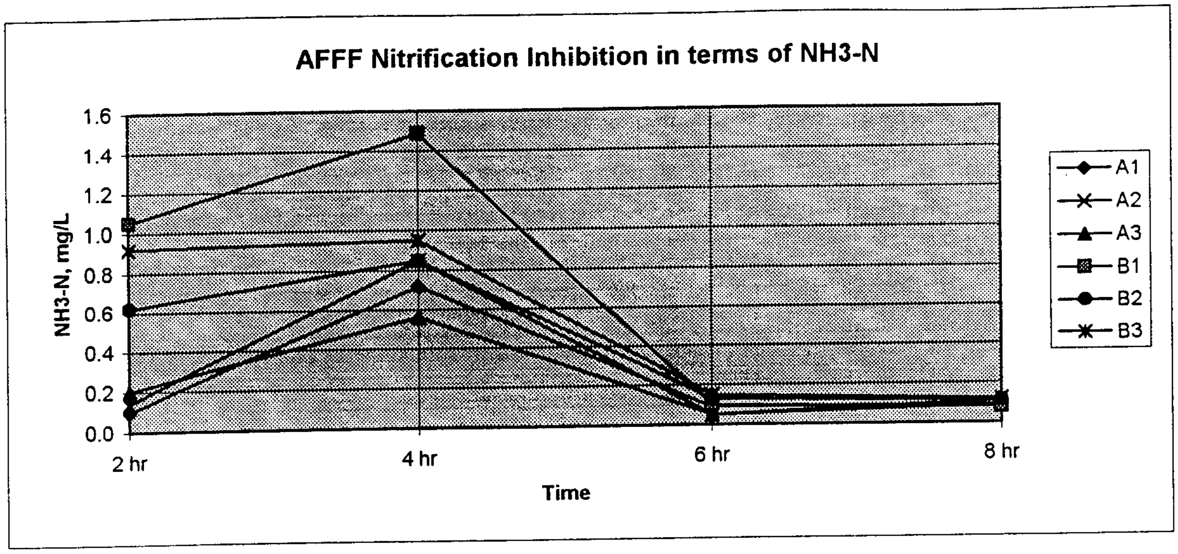
Date of Test: 3-11-97 Standards & Data AFFF Conc. = 10 ppm

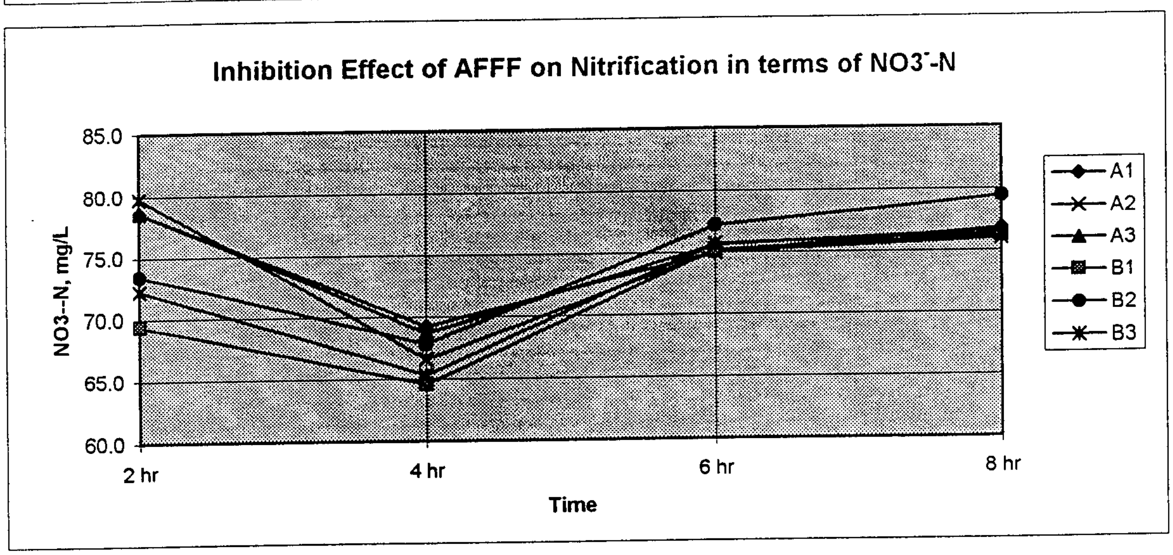
Reactor	AFFF (ppm)	Stage	Time	Cl- Area	Cl- (mg/L)	NO_2^--N Area	NO_2^--N (mg/L)	NO_3^--N Area	NO_3^--N (mg/L)	PO_4^--P Area	PO_4^--P (mg/L)
		Feedstock		6715628784	269.8	0	0.0	2781236	0.0	-1.1	1.2
		RR Decant		7379999536	296.5	0	0.0	4889797732	85.4	511148918	26.2
A1	0	End of Feeding	2 hr	6879646937	276.4	242490130	4.4	4496483210	78.6	541183684	27.6
		End of Anaerobic	4 hr	6956095554	279.5	238200220	4.3	3955787769	69.3	535765933	27.4
		End of Aerobic	6 hr	6977735285	280.3	0	0.0	4287109114	75.0	509684010	26.1
		End of Settling	8 hr	7187533449	288.8	0	0.0	4393981352	76.9	528011628	27.0
A2	0	End of Feeding	2 hr	7098286417	285.2	279135981	5.3	4564554880	79.8	570015263	29.0
		End of Anaerobic	4 hr	6921165144	278.1	292355659	5.6	3801489532	66.6	544266226	27.8
		End of Aerobic	6 hr	6988448355	280.8	0	0.0	4291229979	75.1	517807469	26.5
		End of Settling	8 hr	7158838165	287.6	0	0.0	4342356980	76.0	533776772	27.3
A3	0	End of Feeding	2 hr	7029526084	282.4	260440363	4.9	4496988180	78.6	563165700	28.7
		End of Anaerobic	4 hr	6992881661	280.9	232915668	4.2	3922789396	68.7	552725458	28.2
		End of Aerobic	6 hr	7060096663	283.6	0	0.0	4323098950	75.6	528417431	27.0
		End of Settling	8 hr	7219718175	290.1	0	0.0	4383357748	76.7	544802116	27.8
B1	10	End of Feeding	2 hr	6750790338	271.2	355735497	7.0	3964329569	69.4	546195529	27.9
		End of Anaerobic	4 hr	6945089893	279.0	339539410	6.7	3685493964	64.6	553849967	28.2
		End of Aerobic	6 hr	7041326812	282.9	0	0.0	4298145469	75.2	528330321	27.0
		End of Settling	8 hr	7110540229	285.7	0	0.0	4356112634	76.2	538223784	27.5
B2	10	End of Feeding	2 hr	7023664970	282.2	351463700	6.9	4195401940	73.4	577613190	29.4
		End of Anaerobic	4 hr	6971067504	280.1	327920060	6.4	3872442285	67.8	550799097	28.1
		End of Aerobic	6 hr	6884724090	276.6	0	0.0	4415165915	77.2	534962159	27.3
		End of Settling	8 hr	7214576565	289.8	0	0.0	4542997159	79.4	547601247	27.9
B3	10	End of Feeding	2 hr	7019850376	282.0	358145216	7.1	4125324293	72.2	580301097	29.5
		End of Anaerobic	4 hr	6945483217	279.0	327569990	6.4	3728934453	65.3	561396118	28.6
		End of Aerobic	6 hr	7102629168	285.3	70668616	0.0	4327925541	75.7	550672501	28.1
		End of Settling	8 hr	7168360628	288.0	0	0	4365704270	76.4	552395127	28.2
		Standards used									
		STD 1		0	0	0	0	0	0	0	0
		STD 2		4989643578	200	513178539	10	502863940	10	166413160	10
		STD 3		6189034544	250	976542180	20	1070159911	20	353794617	20
		STD 4		7487358505	300	1759050625	40	2294176939	40	814138794	40
		Stand 2		5041208659	202.6	525911562	10.9	507607399	9.5	167414072	9.4
		Stand 3		6241485978	250.8	980871599	21.4	1082151785	19.5	359320676	18.8
		Stand 4		7467287380	300.0		0.0		0.0		1.2

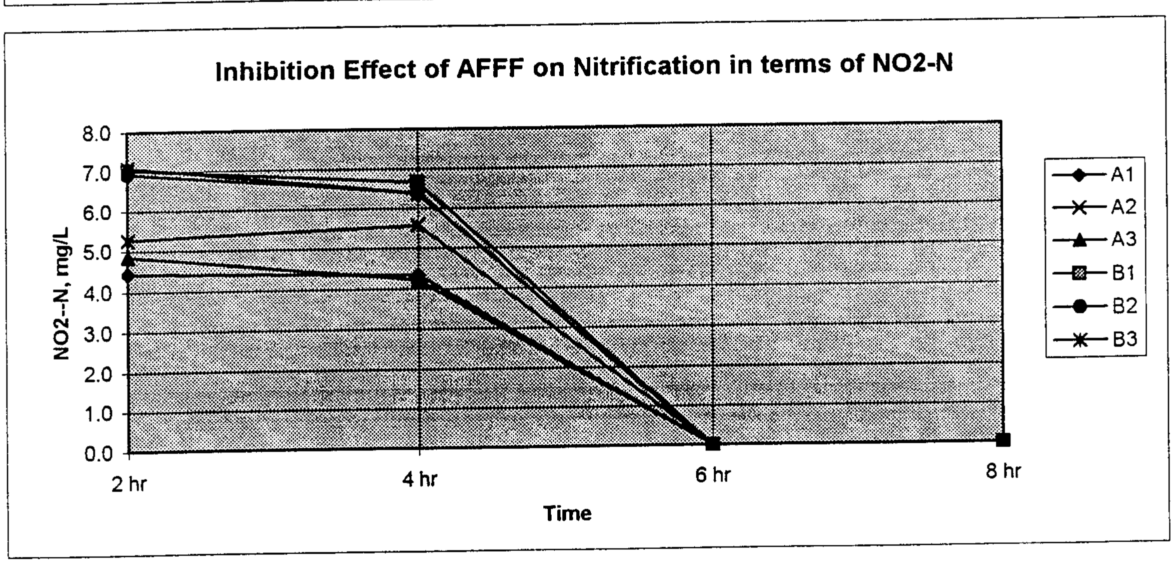
Date of Test: 3-11-97 Concentrations Table AFFF Conc. = 10 ppm

Reactor	AFFF (ppm)	Stage	Time	pH	Concentration, mg/L TKN	NH3-N	Org. N	NO2--N	NO3--N	Total N	Cl-	PO4-P
		Feedstock		6.7	323.7	10.6	313.1	0.0	0.0	323.7	269.8	1.2
		RR Decant		7.3	8.8	0.2	8.6	0.0	85.4	94.2	296.5	26.2
A1	0	End of Feeding	2 hr	7.2	16.0	0.1	15.9	4.4	78.6	99.0	276.4	27.6
		End of Anaerobic	4 hr	7.3	21.9	0.7	21.1	4.3	69.3	95.5	279.5	27.4
		End of Aerobic	6 hr	7.5	9.4	0.1	9.4	0.0	75.0	84.4	280.3	26.1
		End of Settling	8 hr	7.4	15.4	0.1	15.3	0.0	76.9	92.3	288.8	27.0
A2	0	End of Feeding	2 hr	7.2	7.4	0.1	7.3	5.3	79.8	92.5	285.2	29.0
		End of Anaerobic	4 hr	7.3	17.7	0.9	16.9	5.6	66.6	89.9	278.1	27.8
		End of Aerobic	6 hr	7.6	10.9	0.1	10.8	0.0	75.1	85.9	280.8	26.5
		End of Settling	8 hr	7.5	20.4	0.1	20.3	0.0	76.0	96.4	287.6	27.3
A3	0	End of Feeding	2 hr	7.3	10.5	0.2	10.3	4.9	78.6	94.0	282.4	28.7
		End of Anaerobic	4 hr	7.3	17.1	0.6	16.6	4.2	68.7	90.0	280.9	28.2
		End of Aerobic	6 hr	7.7	18.4	0.1	18.3	0.0	75.6	94.0	283.6	27.0
		End of Settling	8 hr	7.5	27.9	0.1	27.8	0.0	76.7	104.6	290.1	27.8
B1	10	End of Feeding	2 hr	7.2	17.1	1.1	16.1	7.0	69.4	93.6	271.2	27.9
		End of Anaerobic	4 hr	7.3	21.1	1.5	19.6	6.7	64.6	92.4	279.0	28.2
		End of Aerobic	6 hr	7.8	19.7	0.1	19.6	0.0	75.2	94.9	282.9	27.0
		End of Settling	8 hr	7.6	34.5	0.1	34.4	0.0	76.2	110.7	285.7	27.5
B2	10	End of Feeding	2 hr	7.2	17.1	0.6	16.5	6.9	73.4	97.5	282.2	29.4
		End of Anaerobic	4 hr	7.2	18.4	0.9	17.5	6.4	67.8	92.6	280.1	28.1
		End of Aerobic	6 hr	7.7	24.3	0.1	24.2	0.0	77.2	101.5	276.6	27.3
		End of Settling	8 hr	7.7	30.0	0.1	29.9	0.0	79.4	109.4	289.8	27.9
B3	10	End of Feeding	2 hr	7.2	23.5	0.9	22.5	7.1	72.2	102.7	282.0	29.5
		End of Anaerobic	4 hr	7.2	19.7	1.0	18.7	6.4	65.3	91.4	279.0	28.6
		End of Aerobic	6 hr	7.7	27.9	0.2	27.8	0.0	75.7	103.6	285.3	28.1
		End of Settling	8 hr	7.7	30.0	0.1	29.8	0.0	76.4	106.3	288.0	28.2

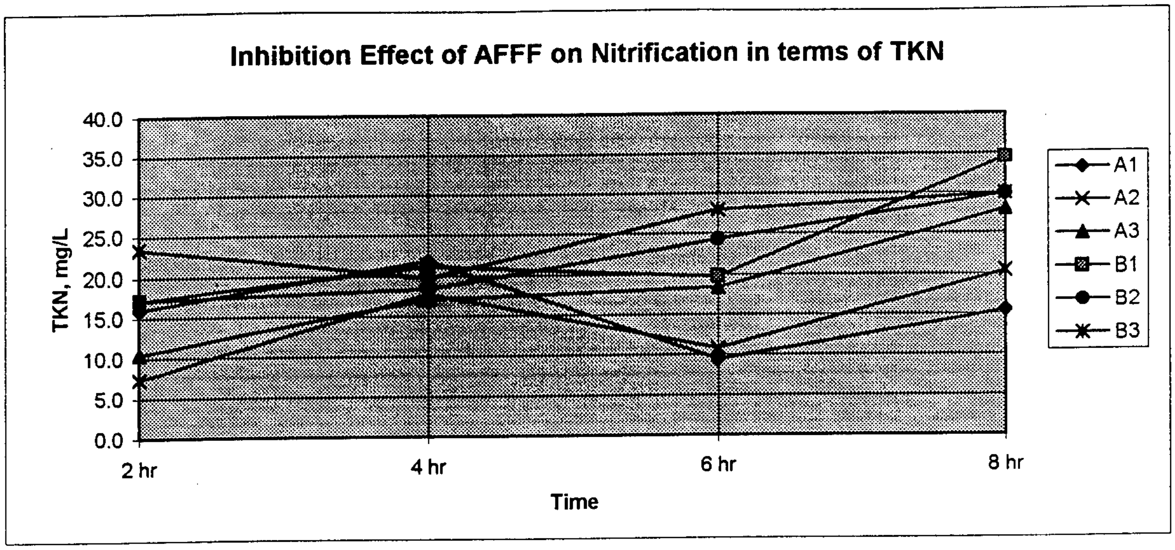
Date of Test: 3-11-97 NH3-N & TKN Charts AFFF Conc. = 10 ppm



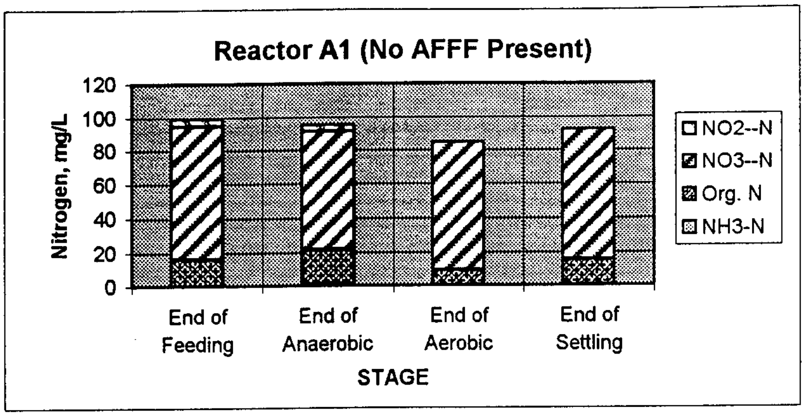


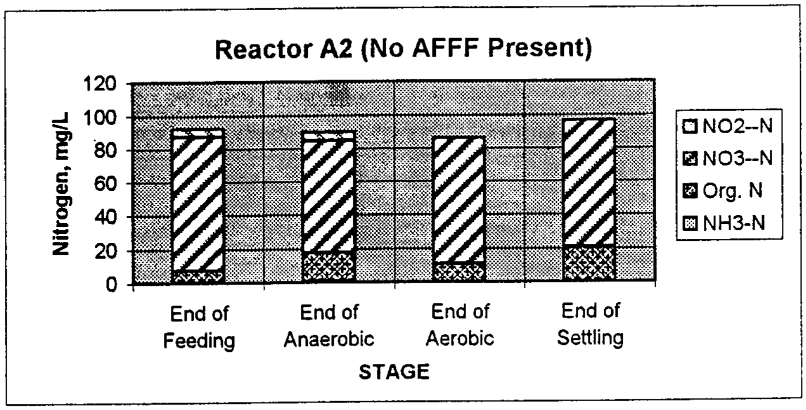


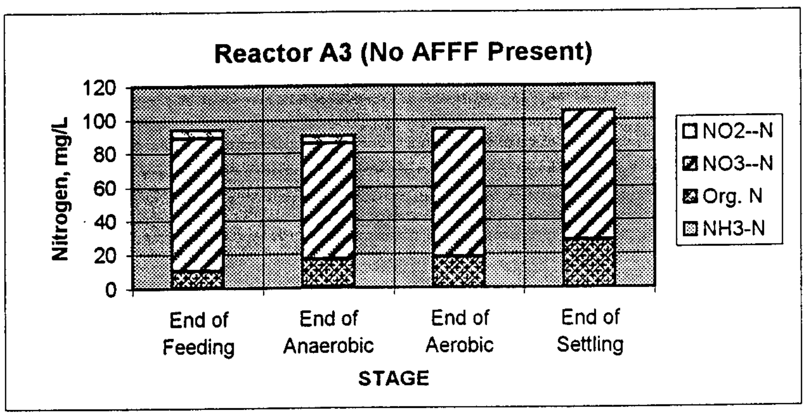
Date of Test: 3-11-97 NH3-N & TKN Charts AFFF Conc. = 10 ppm



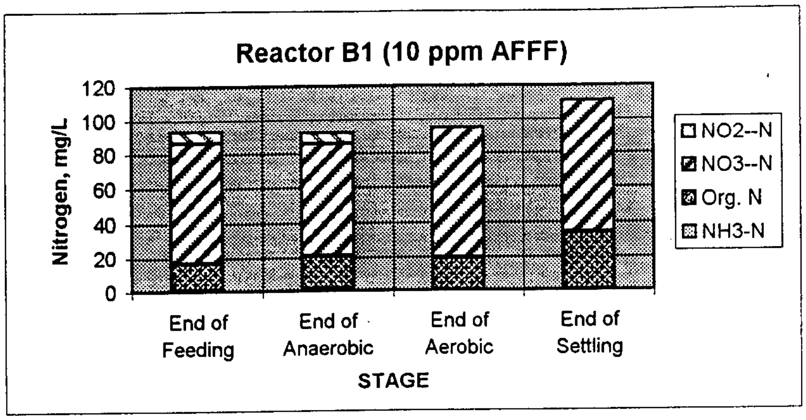
Date of Test: 3-11-97 Inhibition Reactors / Nitrogen Mass Balance AFFF Conc. = 10 ppm

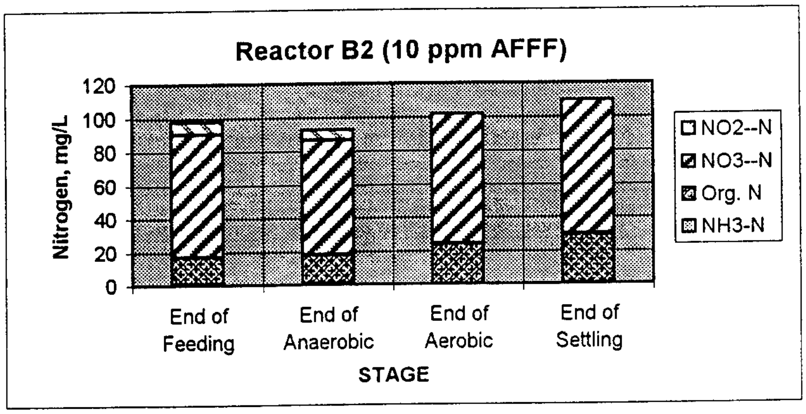


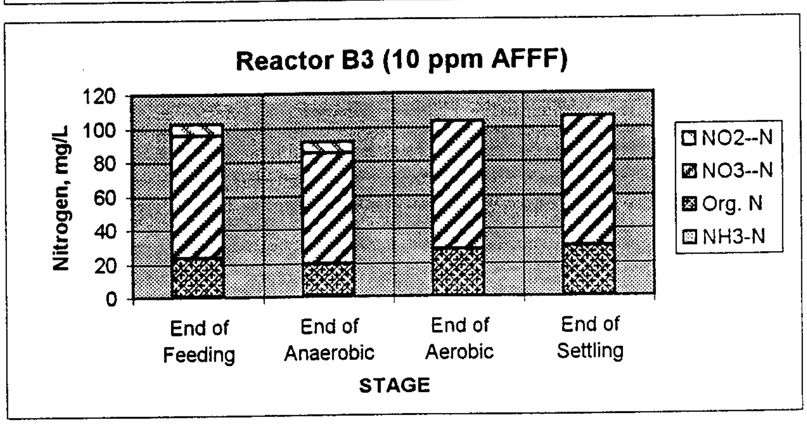




Date of Test: 3-11-97 Inhibition Reactors / Nitrogen Mass Balance AFFF Conc. = 10 ppm

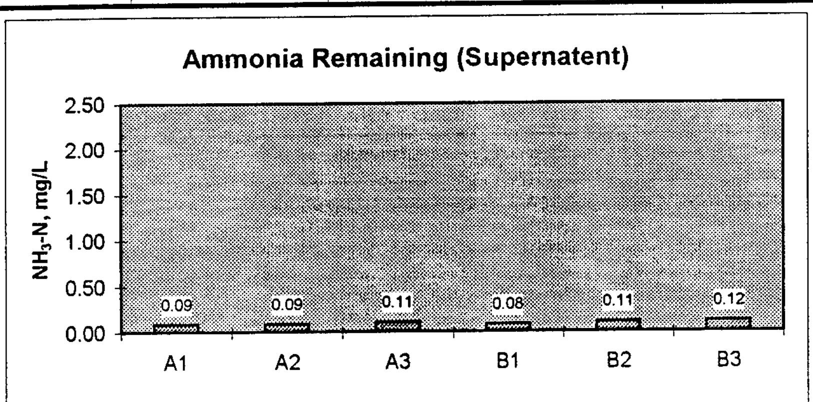


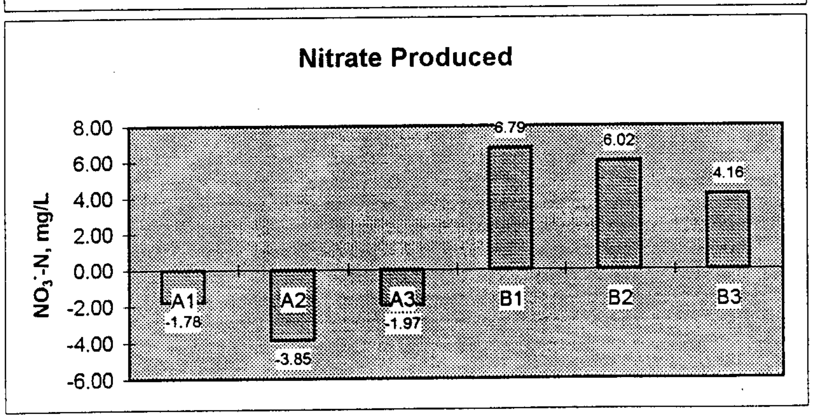




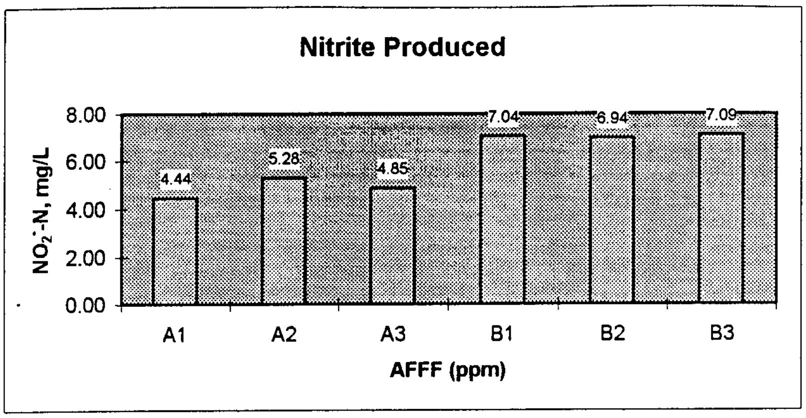
Date of Test: 3-11-97 | Inhibition Reactors / NO3- & NO2 Produced | AFFF Conc. = 10 ppm

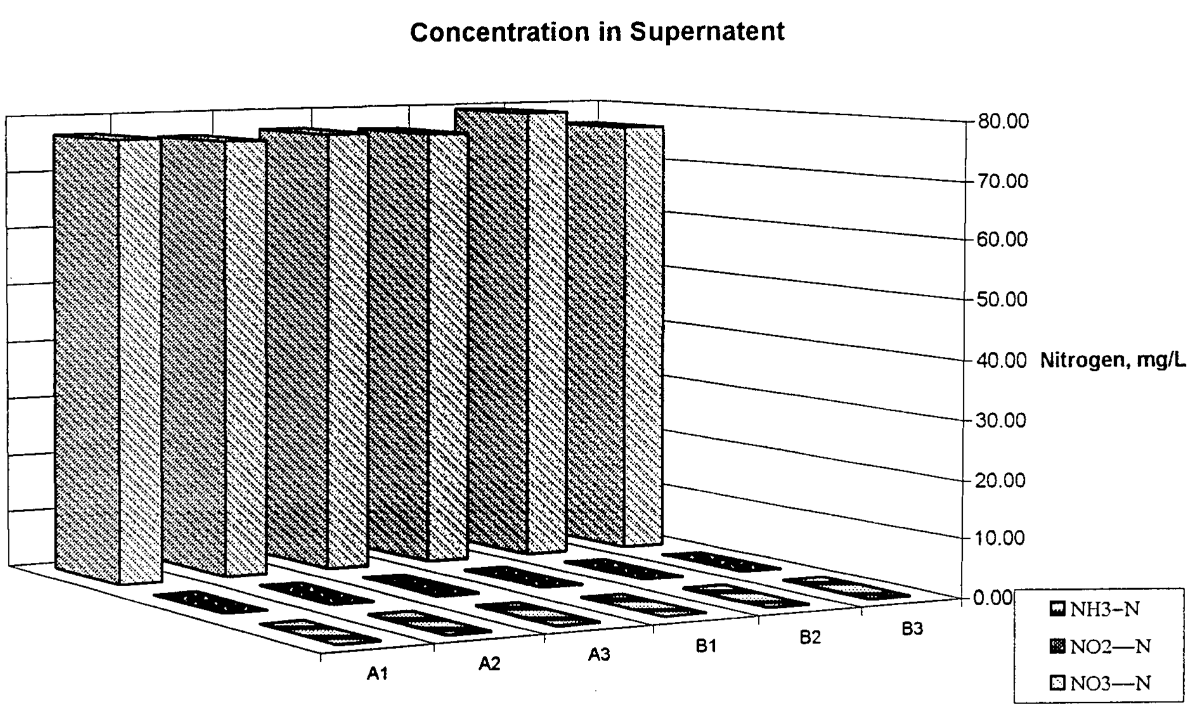
Reactor	AFFF ppm	Stage	Time	NH3-N	NO3--N	NO2--N	$\Delta(NO_3^-\text{-N})$	$\Delta(NO_2\text{-N})$
				Nitrogen Concentration, mg/L				
A1	0	End of Feeding	2 hr	0.10	78.6	4.4		
(Control)		End of Anaerobic	4 hr	0.72	69.3	4.3		
		End of Aerobic	6 hr	0.09	75.0	0.0		
		End of Settling	8 hr	0.09	76.9	0.0	-1.78	4.44
A2	0	End of Feeding	2 hr	0.14	79.8	5.3		
(Control)		End of Anaerobic	4 hr	0.85	66.6	5.6		
		End of Aerobic	6 hr	0.05	75.1	0.0		
		End of Settling	8 hr	0.09	76.0	0.0	-3.85	5.28
A3	0	End of Feeding	2 hr	0.20	78.6	4.9		
(Control)		End of Anaerobic	4 hr	0.56	68.7	4.2		
		End of Aerobic	6 hr	0.05	75.6	0.0		
		End of Settling	8 hr	0.11	76.7	0.0	-1.97	4.85
B1	10	End of Feeding	2 hr	1.05	69.4	7.0		
		End of Anaerobic	4 hr	1.49	64.6	6.7		
		End of Aerobic	6 hr	0.10	75.2	0.0		
		End of Settling	8 hr	0.08	76.2	0.0	6.79	7.04
B2	10	End of Feeding	2 hr	0.62	73.4	6.9		
		End of Anaerobic	4 hr	0.85	67.8	6.4		
		End of Aerobic	6 hr	0.13	77.2	0.0		
		End of Settling	8 hr	0.11	79.4	0.0	6.02	6.94
B3	10	End of Feeding	2 hr	0.92	72.2	7.1		
		End of Anaerobic	4 hr	0.95	65.3	6.4		
		End of Aerobic	6 hr	0.15	75.7	0.0		
		End of Settling	8 hr	0.12	76.4	0.0	4.16	7.09





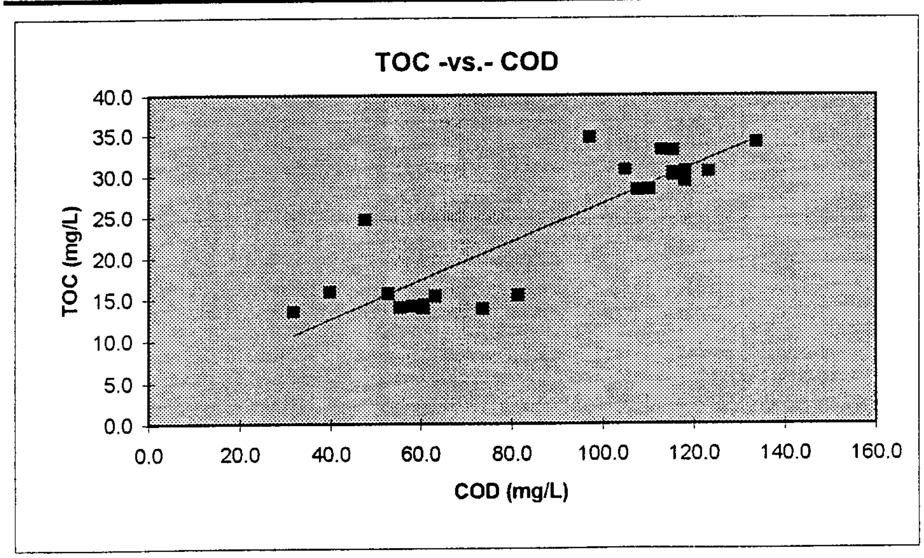
Date of Test: 3-11-97 Inhibition Reactors / NO3- & NO2 Produced AFFF Conc. = 10 ppm





Date of Test: 3-11-97 Concentrations Table AFFF Conc. = 10 ppm

Reactor	AFFF (ppm)	Stage	Time	Concentration, mg/L TCOD	COD	TOC	Alkalinity HCO3 (mg/l)
		Feedstock		0.0	1198.1	415.5	318
		RR Decant		0.0	61.9	15.5	224
A1	0	End of Feeding	2 hr	1009.8	60.5	14.3	204.5
		End of Anaerobic	4 hr	719.5	47.5	24.7	202
		End of Aerobic	6 hr	588.8	81.5	15.4	215
		End of Settling	8 hr	68.4	63.2	15.4	220.5
A2	0	End of Feeding	2 hr	0.0	52.7	15.7	177
		End of Anaerobic	4 hr	0.0	31.8	13.6	204
		End of Aerobic	6 hr	0.0	73.6	13.8	164
		End of Settling	8 hr	0.0	55.3	14.0	162.5
A3	0	End of Feeding	2 hr	0.0	39.6	15.9	168.5
		End of Anaerobic	4 hr	0.0	60.5	13.9	192
		End of Aerobic	6 hr	0.0	63.2	15.4	136.5
		End of Settling	8 hr	0.0	57.9	14.2	173
B1	10	End of Feeding	2 hr	811.1	112.8	33.2	207
		End of Anaerobic	4 hr	1172.0	118.1	30.6	204.5
		End of Aerobic	6 hr	144.2	110.2	28.3	129
		End of Settling	8 hr	136.4	118.1	29.4	133
B2	10	End of Feeding	2 hr	0.0	133.8	34.1	195.5
		End of Anaerobic	4 hr	0.0	105.0	30.8	198
		End of Aerobic	6 hr	0.0	115.5	30.1	126
		End of Settling	8 hr	0.0	115.5	30.4	126.5
B3	10	End of Feeding	2 hr	0.0	115.5	33.2	185
		End of Anaerobic	4 hr	0.0	97.2	34.8	201
		End of Aerobic	6 hr	0.0	107.6	28.3	133
		End of Settling	8 hr	0.00	123.3	30.5	132.5
		FS1 (Filtered)			1271.3	404.3	
		FS2 (Filtered)			1124.9	426.7	
		FS Average			1198.1	415.5	
		RRSU1 (Filtered)			60.5	15.5	
		RRSU2 (Filtered)			63.2	15.4	
		RRSU Average			61.9	15.5	



Date of Test: 3-11-97 COD Concentration and % Removal AFFF Conc. = 10 ppm

Reactor	AFFF (ppm)	Stage	Time	COD ABS	COD (mg/L)	COD % COD Removal*	Total COD ABS	Total COD (mg/L)
		Feedstock		0.460	**1198.1**			
		RR Decant		0.026	**61.9**			
A1	0	End of Feeding	2 hr	0.025	**60.5**	86.3	0.388	**1009.8**
		End of Anaerobic	4 hr	0.020	**47.5**	89.2	0.277	**719.5**
		End of Aerobic	6 hr	0.033	**81.5**	81.5	0.227	**588.8**
		End of Settling	8 hr	0.026	**63.2**	**85.7**	0.028	**68.4**
A2	0	End of Feeding	2 hr	0.022	**52.7**	88.0		
		End of Anaerobic	4 hr	0.014	**31.8**	92.8		
		End of Aerobic	6 hr	0.030	**73.6**	83.3		
		End of Settling	8 hr	0.023	**55.3**	**87.4**		
A3	0	End of Feeding	2 hr	0.017	**39.6**	91.0		
		End of Anaerobic	4 hr	0.025	**60.5**	86.3		
		End of Aerobic	6 hr	0.026	**63.2**	85.7		
		End of Settling	8 hr	0.024	**57.9**	**86.9**		
B1	10	End of Feeding	2 hr	0.045	**112.8**	81.1	0.312	**811.1**
		End of Anaerobic	4 hr	0.047	**118.1**	80.2	0.450	**1172.0**
		End of Aerobic	6 hr	0.044	**110.2**	81.5	0.057	**144.2**
		End of Settling	8 hr	0.047	**118.1**	**80.2**	0.054	**136.4**
B2	10	End of Feeding	2 hr	0.053	**133.8**	77.5		
		End of Anaerobic	4 hr	0.042	**105.0**	82.4		
		End of Aerobic	6 hr	0.046	**115.5**	80.6		
		End of Settling	8 hr	0.046	**115.5**	**80.6**		
B3	10	End of Feeding	2 hr	0.046	**115.5**	80.6		
		End of Anaerobic	4 hr	0.039	**97.2**	83.7		
		End of Aerobic	6 hr	0.043	**107.6**	81.9		
		End of Settling	8 hr	0.049	**123.3**	**79.3**		
		STD 1		0.000	0			
		STD 2		0.100	250			
		STD 3		0.193	500			
		STD 4		0.289	750			
		STD 5		0.345	900			
		FS1 (Filtered)		0.488	1271.3			
		FS2 (Filtered)		0.432	1124.9			
		FS Average		**0.460**	**1198.1**			
		RRSU1 (Filtered)		0.025	60.5			
		RRSU2 (Filtered)		0.026	63.2			
		RRSU Average		**0.026**	**61.9**			

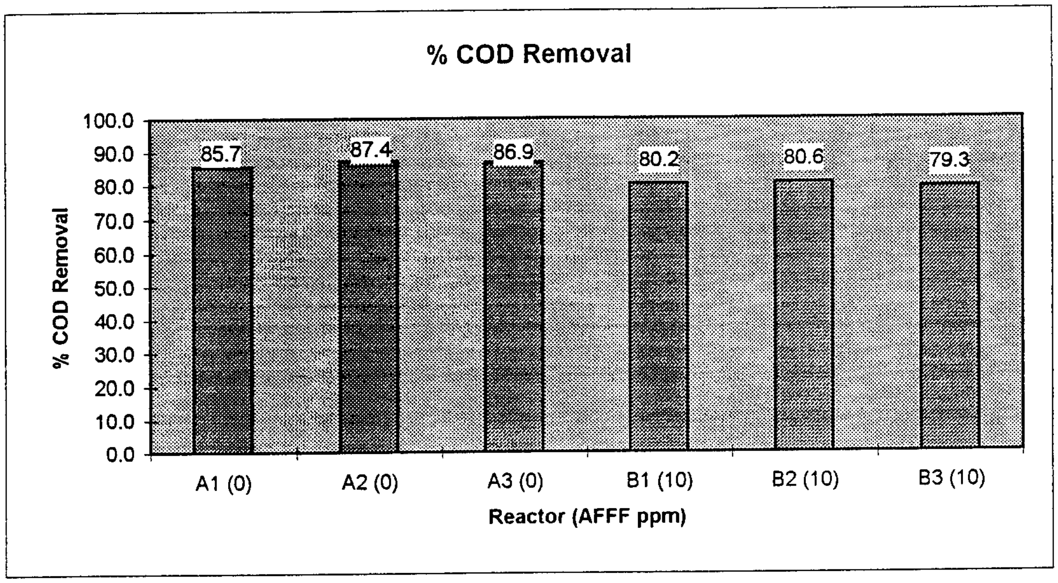
* The values of "COD % Removal" shown in table and chart above are accumulative figures based on the initial COD concentration at time 0 hr.

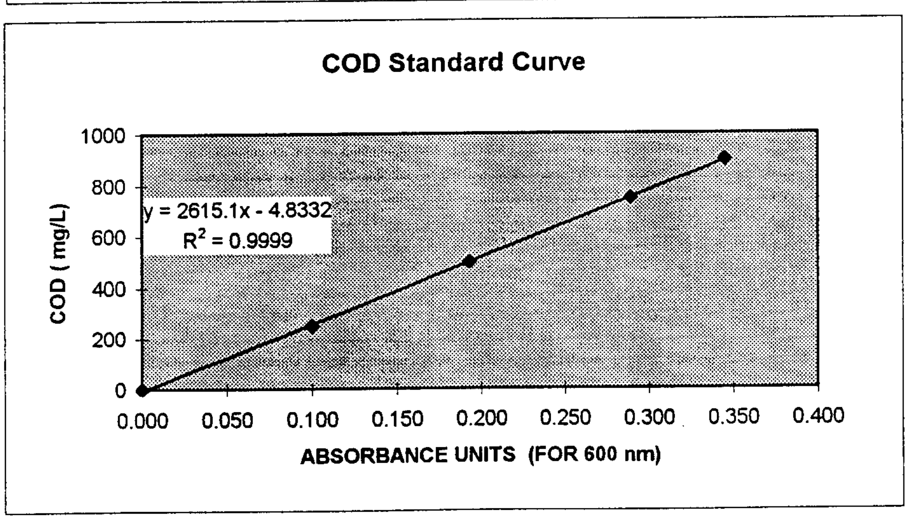
Date of Test: 3-11-97 COD Concentration and % Removal AFFF Conc. = 10 ppm

Initial COD at Time 0 hr.

Sample	Constituent	Vol (L)	COD mg/L	(AFFF+ Feed) COD mg/l
Controls	RR Decant	4	61.9	247.4074
(A1,A2&A3)	Feedstock	2	1198.1	2396.2256
	AFFF	0	0	0
	Total	6		**440.6**
Inhibition	RR Decant	4	30.25	121
(B1,B2&B3)	Feedstock	2	922.75	1845.5
	AFFF	2	803.95	1607.9
	Total	6		**595.7**

Reactor (AFFF ppm)	A1 (0)	A2 (0)	A3 (0)	B1 (10)	B2 (10)	B3 (10)
% COD Removal	85.7	87.4	86.9	80.2	80.6	79.3





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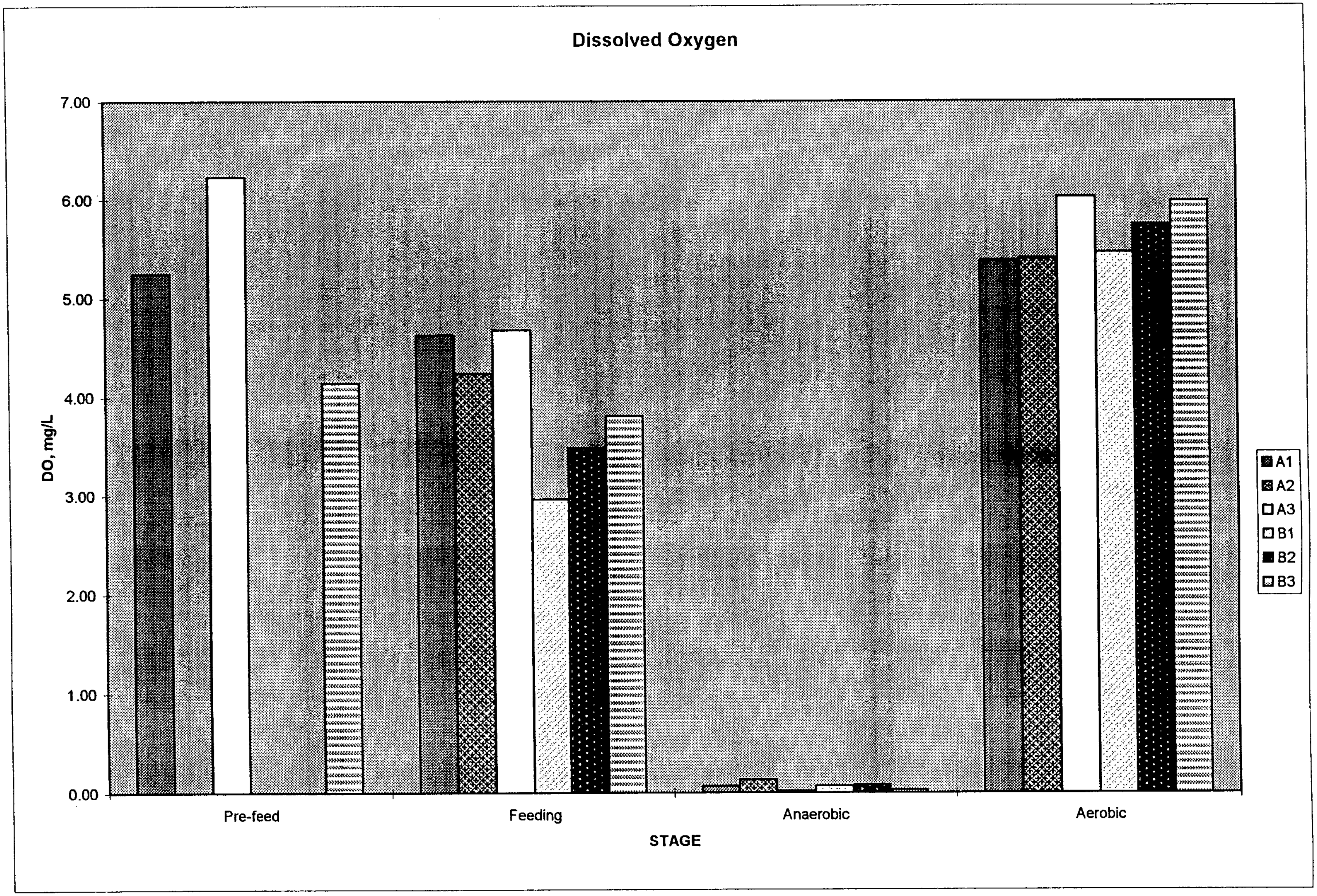
i = *-4.8332*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DO, mg/L
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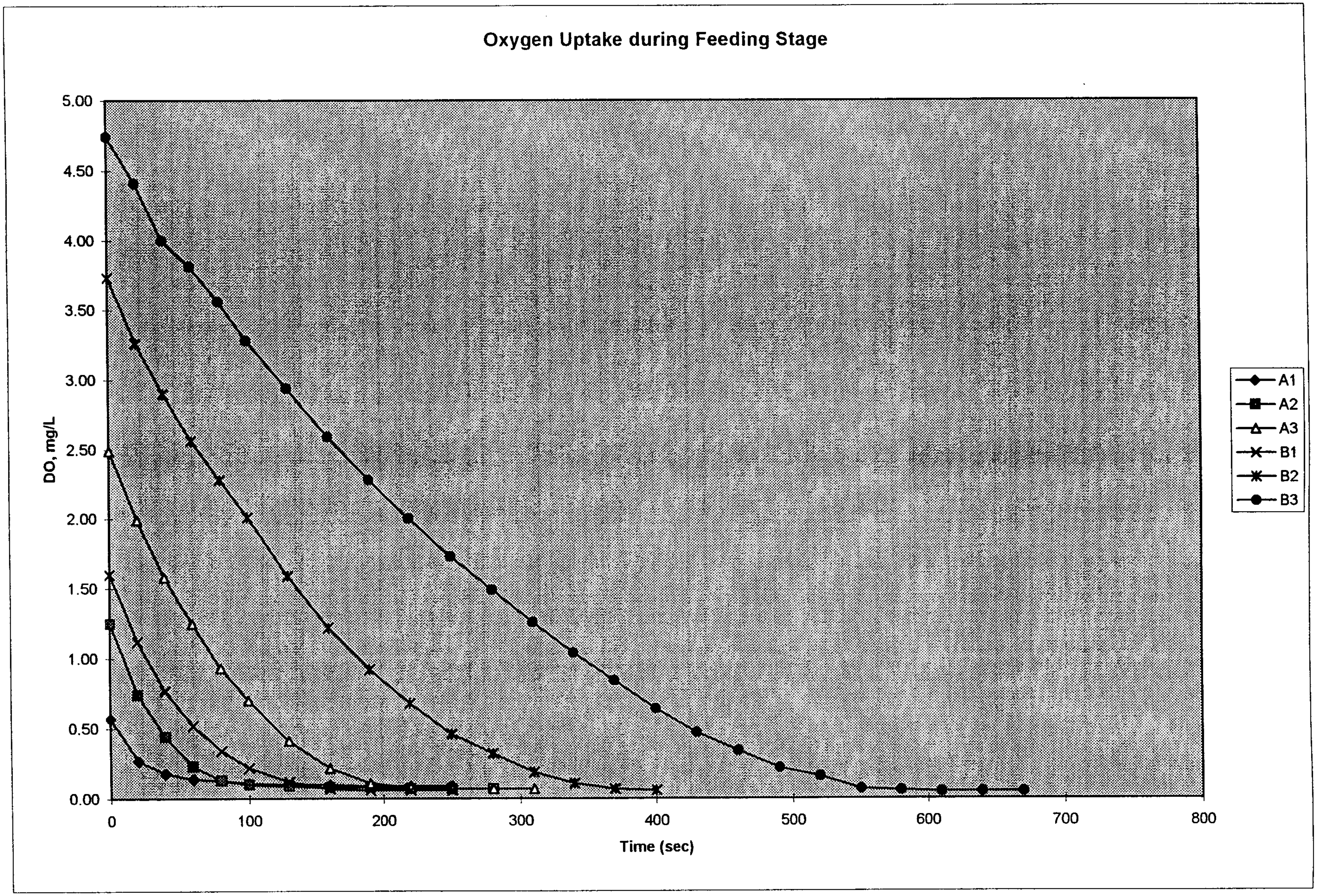
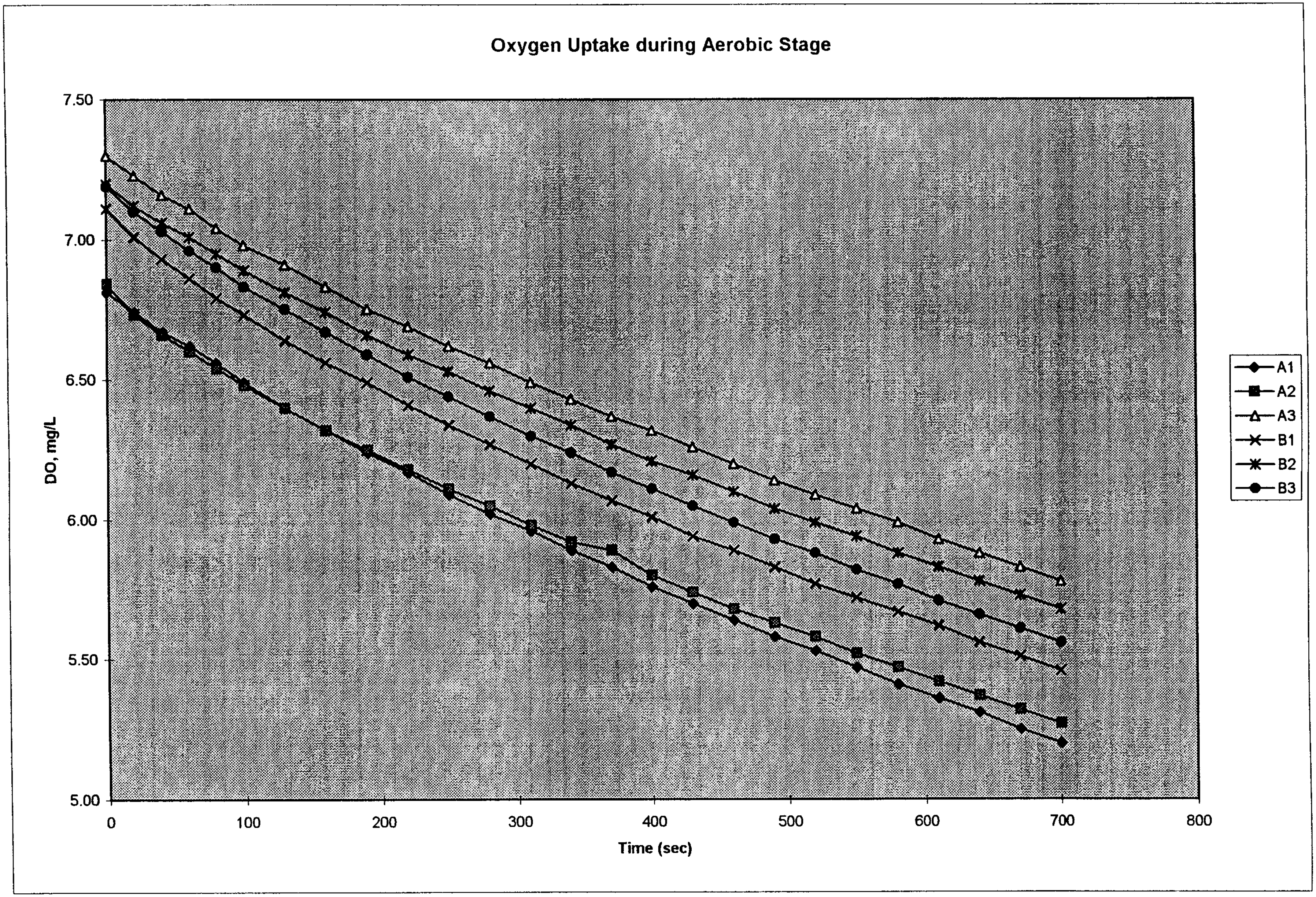
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Pre-feed
Feeding
Anaerobic
Aerobic
STAGE
A1
A2
A3
B1
B2
B3

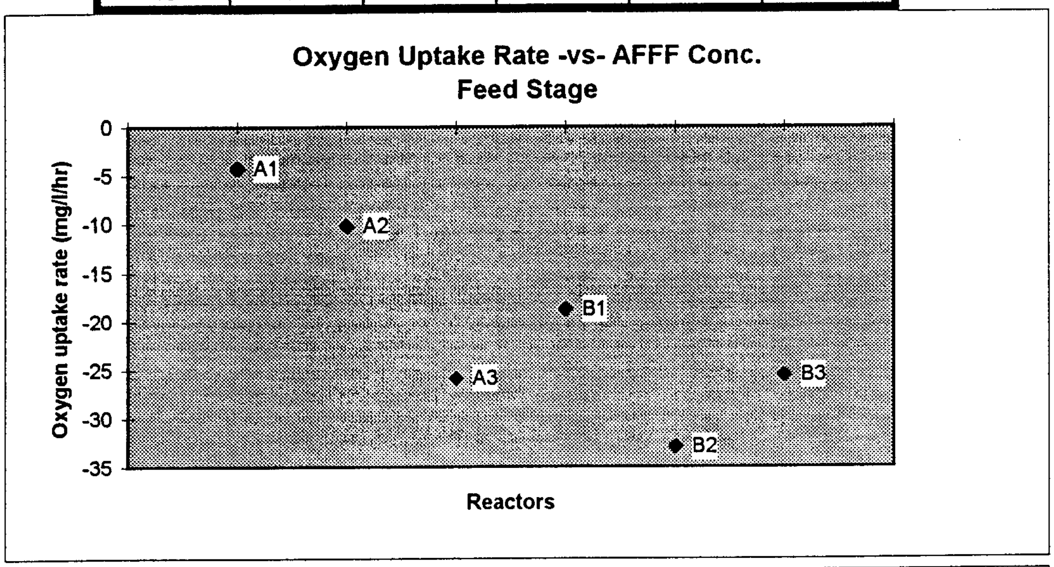

Oxygen Uptake during Feeding Stage
DO, mg/L
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
100
200
300
400
500
600
700
800
Time (sec)
A1
A2
A3
B1
B2
B3

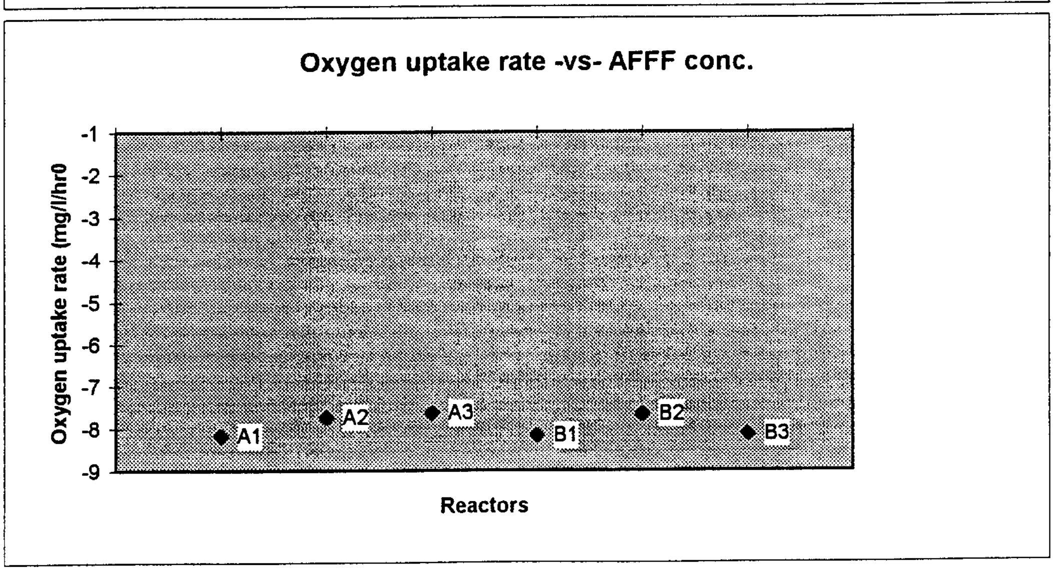


Oxygen Uptake during Aerobic Stage
DO, mg/L
7.50
7.00
6.50
6.00
5.50
5.00
0
100
200
300
400
500
600
700
800
Time (sec)
A1
A2
A3
B1
B2
B3

Regression Summary

AFFF			Feed stage		
ppm	Samples	R square	Intercept	Slopemg/l/sec	Slopemg/l/hr
0	A1	0.4683	0.3036	-0.00118	-4.248
0	A2	0.5116	0.6399	-0.00283	-10.188
0	A3	0.7939	1.7846	-0.00719	-25.884
10	B1	0.7086	1.0403	-0.0052	-18.72
10	B2	0.9173	3.0829	-0.00914	-32.904
10	B3	0.9215	3.9268	-0.0071	-25.56
AFFF			Aerobic Stage		
ppm	Samples	R square	Intercept	Slopemg/l/sec	Slopemg/l/hr
0	A1	0.9912	6.7132	-0.00227	-8.172
0	A2	0.9893	6.7018	-0.00215	-7.74
0	A3	0.9913	7.1992	-0.00212	-7.632
10	B1	0.987	6.963	-0.00227	-8.172
10	B2	0.9922	7.103	-0.00213	-7.668
10	B3	0.989	7.063	-0.00226	-8.136





SOUR CALCULATION

		Feed stage			Aerobic stage
AFFF (ppm)	Samples	slope mg/l/hr	slopemg/l/hr/VSS	slope mg/l/hr	slopemg/l/hr/VSS
0	A1	-4.248	-0.00165485	-8.172	-0.00318348
0	A2	-10.188	-0.0039906	-7.74	-0.00303173
0	A3	-25.884	-0.009156	-7.632	-0.00269968
10	B1	-18.72	-0.00782282	-8.172	-0.00341496
10	B2	-32.904	-0.01410373	-7.668	-0.00328676
10	B3	-25.56	-0.01079848	-8.136	-0.00343726

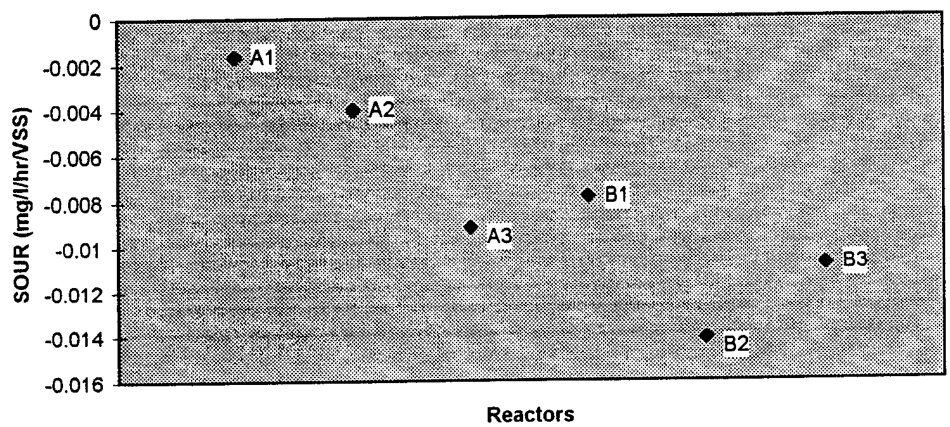


Figure 3-6: Specific Oxygen uptake rates (SOUR's) during the feed stage for 10 ppm AFFF (A--Control, B--Inhibition)

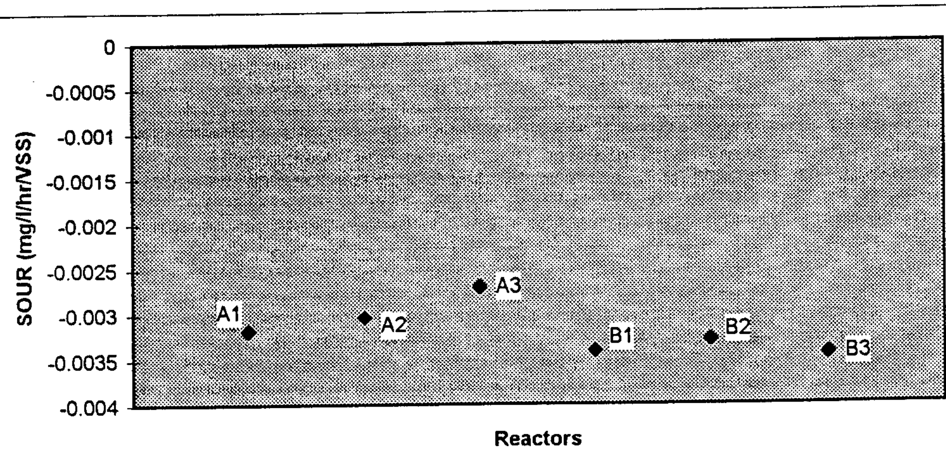


Figure 3-7: Specific Oxygen uptake rates (SOUR's) during the aerobic stage for 10 ppm AFFF (A--Control, B--Inhibition)

Date of Test: 3-11-97 BOD$_5$ of Inhibition Run AFFF Conc. = 10 ppm

Date, initial: 3/11/97 Date, final: 3/16/97

	Time 2 hr						
Bottle No.	41	109	116	70	777	103	Remarks
Sample Location	A1	A2	A3	B1	B2	B3	
% Sample in BOD Bottle	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	
Initial D.O. (mg/L)	8.06	8.02	7.89	8.07	8.03	7.89	
Final D.O. (mg/L)	6.98	7.02	6.75	0.07	0.09	0.06	Note 4
D.O. Depletion	1.08	1.00	1.14	8.00	7.94	7.83	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	0.4	0.4	0.4	0.4	0.4	0.4	
BOD of Sample	3	2	3	30	30	30	
Average BOD (mg/L)		3			30		

	Time 4 hr						
Bottle No.	28	999	75	111	23	187	Remarks
Sample Location	A1	A2	A3	B1	B2	B3	
% Sample in BOD Bottle	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	
Initial D.O. (mg/L)	7.73	7.75	7.79	7.78	7.88	7.72	
Final D.O. (mg/L)	6.75	6.80	6.81	0.07	0.08	0.08	Note 4
D.O. Depletion	0.98	0.95	0.98	7.71	7.80	7.64	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	0.4	0.4	0.4	0.4	0.4	0.4	
BOD of Sample	2	2	2	29	30	29	
Average BOD (mg/L)		2			29		

	Time 6 hr						
Bottle No.	114	10	L6	268	25A	48	Remarks
Sample Location	A1	A2	A3	B1	B2	B3	
% Sample in BOD Bottle	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	
Initial D.O. (mg/L)	7.67	7.72	7.61	7.57	7.55	7.57	
Final D.O. (mg/L)	6.83	6.87	6.78	0.06	0.07	0.04	Note 4
D.O. Depletion	0.84	0.85	0.83	7.51	7.48	7.53	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	0.4	0.4	0.4	0.4	0.4	0.4	
BOD of Sample	2	2	2	28	28	28	
Average BOD (mg/L)		2			28		

	Time 8 hr						
Bottle No.	268	999	108	187	666	53	Remarks
Sample Location	A1	A2	A3	B1	B2	B3	
% Sample in BOD Bottle	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	
Initial D.O. (mg/L)	7.36	7.55	7.40	7.69	7.33	7.60	
Final D.O. (mg/L)	6.66	6.77	6.60	0.06	0.05	0.06	Note 4
D.O. Depletion	0.70	0.78	0.80	7.63	7.28	7.54	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	0.4	0.4	0.4	0.4	0.4	0.4	
BOD of Sample	1	1	2	29	27	28	
Average BOD (mg/L)		1			28		

Bottle No.	230	56	171	"Seed"	179	112	Blank	
Sample Location	Seed Control	Seed Control	Seed Control	Average	G/G #1	G/G #2	Blank	Remarks
% Sample in BOD Bottle	-	-	-	-	2.0%	2.0%	100.0%	
Initial D.O. (mg/L)	7.79	7.79	7.77	-	7.82	7.75	7.79	
Final D.O. (mg/L)	7.32	7.26	7.50	-	3.36	4.28	7.78	
D.O. Depletion	0.47	0.53	0.27	0.4	4.46	3.47	0.01	Notes 1 & 2
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	-	Note 3
Seed Correction	-	-	-	-	0.4	0.4	-	Note 6
BOD of Sample (mg/L)	47	53	27	42	202	152	0.01	

Bottle No.	888	40	108	666 ***	3 ***	68 ***	Remarks
Sample Location	Feedstock	Feedstock	Feedstock	RRSU	RRSU	RRSU	
% Sample in BOD Bottle	0.5%	0.5%	0.5%	50.0%	50.0%	50.0%	
Initial D.O. (mg/L)	7.76	7.78	7.76	7.71	7.75	7.71	
Final D.O. (mg/L)	3.69	3.63	3.66	3.02	3.24	3.10	Note 4
D.O. Depletion	4.07	4.15	4.10	4.69	4.51	4.61	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	0.4	0.4	0.4	0.4	0.4	0.4	
BOD of Sample (mg/L)	729	745	735	9	8	8	
Average BOD (mg/L)		737			8		

Notes:

1 As per Standard Methods, the Seed Control DO depletion must be between 0.6 and 1.0 mg/L
2. For the Blank, the DO depletion should not be greater than 0.2 mg/L, and preferably not greater than 0.1 mg/L
3. Seed was prepared with 100mL of filtered decant from ref. reactor (collected @ 10am), 100mL of Dilution water, and one Polyseed capsule.
4 The residual DO of samples should be equal or greater than 1 mg/L.
5. The DO depletion of samples should be equal or greater than 2 mg/L.
6. The BOD of Glucose/Glutamic acid should be between 198 + or - 30.5 mg/L.
*** Mistakenly added 1.5 ml of feedstock to RRSU bottles #s 666, 3, and 68.

Appendix IV

Inhibition Test Results at 30 ppm AFFF

Date of Test: 3-19-97

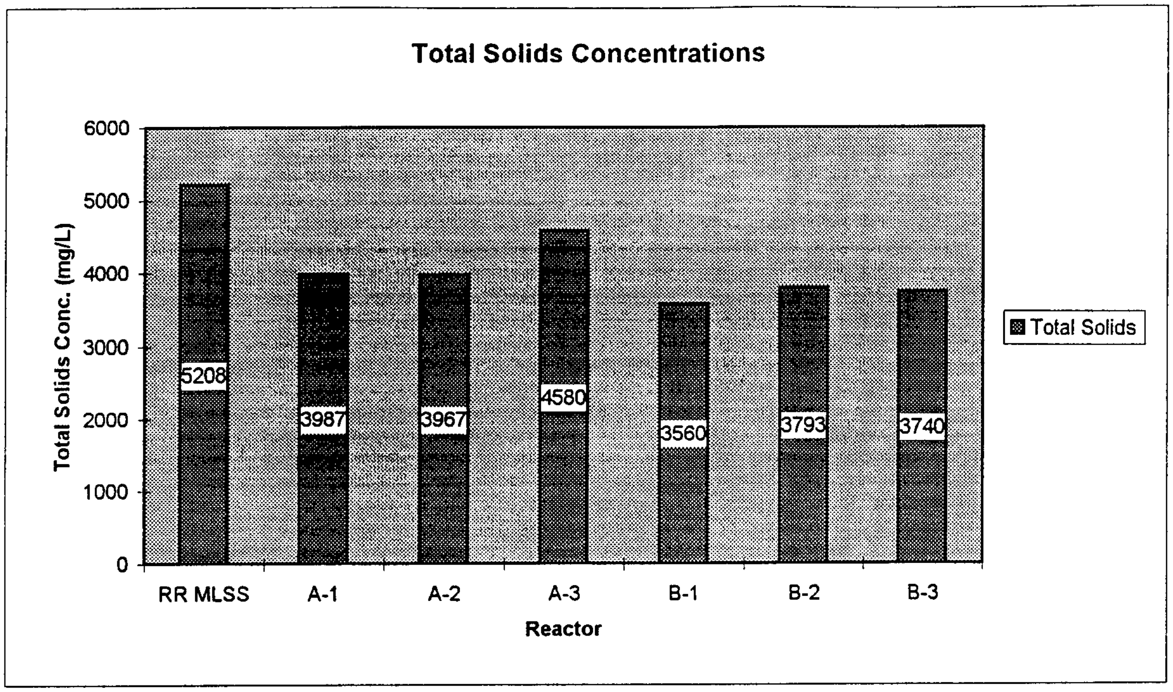
AFFF Conc. = 30 ppm

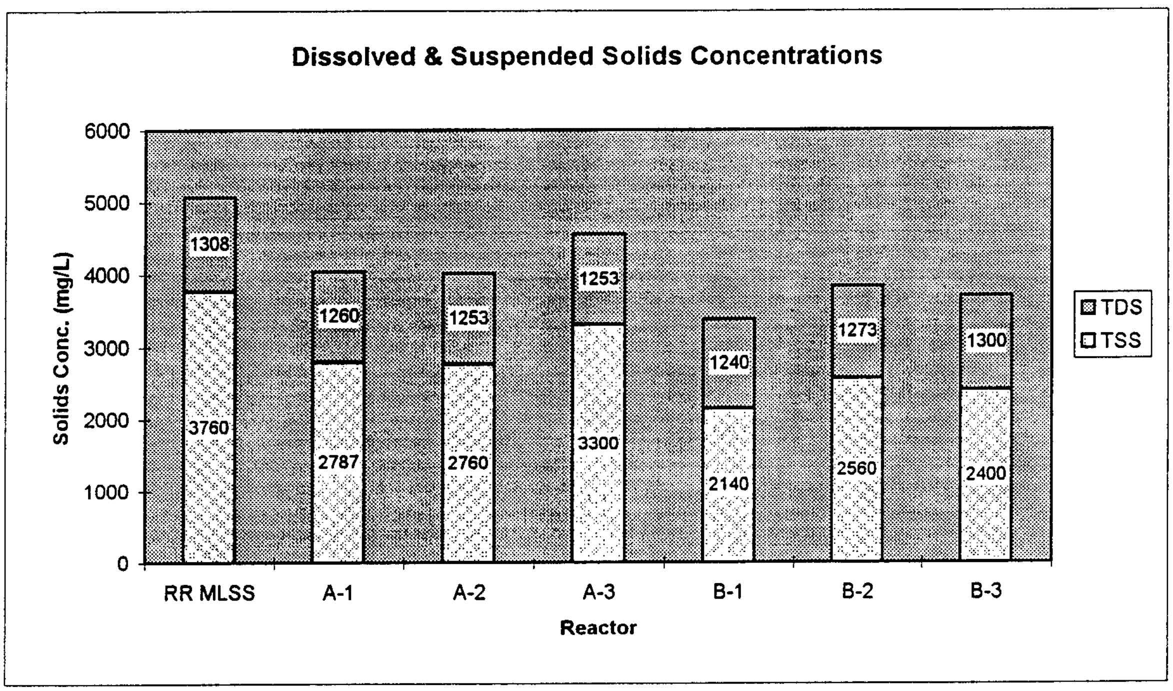
Solids Concentrations

		RR MLSS	A-1	A-2	A-3	B-1	B-2	B-3
			0 ppm AFFF	0 ppm AFFF	0 ppm AFFF	30 ppm AFFF	30 ppm AFFF	30 ppm AFFF
TSS	Empty wt. (gm)	1.0876	1.0907	1.0958	1.1058	1.0931	1.0981	1.0979
	wt.after heat (gm)	1.1816	1.1325	1.1372	1.1553	1.1252	1.1365	1.1339
	SampleVol. (mL)	25	15	15	15	15	15	15
	TSS mg/l	3760	2787	2760	3300	2140	2560	2400
TVS	Initial Weight	1.1816	1.1325	1.1372	1.1553	1.1252	1.1365	1.1339
	wt after 550oC	1.0992	1.0939	1.1028	1.1140	1.0963	1.1020	1.1010
	SampleVol. (mL)	25	15	15	15	15	15	15
	TVS mg/l	3296	2573	2293	2753	1927	2300	2193
TDS	Empty wt. (gm)	0.9899	1.0012	1.0103	1.0037	1.0072	1.0093	0.9941
	wt.after heat (gm)	1.0226	1.0201	1.0291	1.0225	1.0258	1.0284	1.0136
	SampleVol. (mL)	25	15	15	15	15	15	15
	TDS mg/l	1308	1260	1253	1253	1240	1273	1300
TS	Empty wt. (gm)	0.9881	1.0033	1.0155	1.0006	1.0113	1.0118	0.9969
	wt.after heat (gm)	1.1183	1.0631	1.0750	1.0693	1.0647	1.0687	1.0530
	SampleVol. (mL)	25	15	15	15	15	15	15
	TS mg/l	5208	3987	3967	4580	3560	3793	3740
Σ(TSS+TDS)	TS mg/l	5068	4047	4013	4553	3380	3833	3700

Date of Test: 3-19-97

AFFF Conc. = 30 ppm





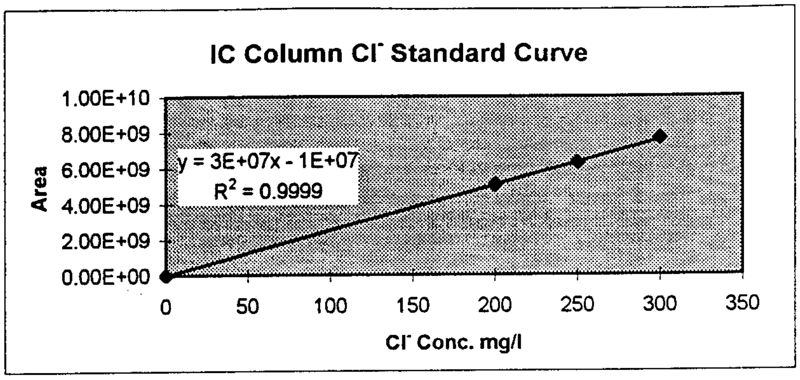
Date of Test: 3-19-97 Standards & Data AFFF Conc. = 30 ppm

Reactor	AFFF (ppm)	Stage	Time	NH3-N (mg/L)	TKN (mg/L)	Alkalinity (mg/L)	pH Units
		Feedstock		35.71	413.85	338	6.72
		RR Decant		0.39	6.19	132.5	7.51
A1	0	End of Feeding	2 hr	6.57	14.58	176	7.24
		End of Anaerobic	4 hr	11.10	14.25	198	7.27
		End of Aerobic	6 hr	0.21	4.88	174.5	7.30
		End of Settling	8 hr	0.30	8.94	129	7.50
A2	0	End of Feeding	2 hr	7.13	20.83	165	7.29
		End of Anaerobic	4 hr	10.66	13.92	211	7.31
		End of Aerobic	6 hr	0.19	7.31	184	7.47
		End of Settling	8 hr	0.32	5.08	142	7.54
A3	0	End of Feeding	2 hr	7.42	15.71	162.5	7.28
		End of Anaerobic	4 hr	11.56	12.34	193.5	7.31
		End of Aerobic	6 hr	0.23	4.88	189	7.49
		End of Settling	8 hr	0.31	5.51	129	7.50
B1	30	End of Feeding	2 hr	10.66	19.22	181.5	7.34
		End of Anaerobic	4 hr	14.72	19.83	181.5	7.29
		End of Aerobic	6 hr	0.33	5.29	114.5	7.52
		End of Settling	8 hr	0.42	5.74	116	7.50
B2	30	End of Feeding	2 hr	11.56	22.58	194	7.21
		End of Anaerobic	4 hr	15.32	25.48	194.5	7.31
		End of Aerobic	6 hr	0.50	9.30	120.5	7.47
		End of Settling	8 hr	0.69	3.01	121.5	7.47
B3	30	End of Feeding	2 hr	10.66	20.01	159	7.27
		End of Anaerobic	4 hr	13.04	22.49	186.5	7.24
		End of Aerobic	6 hr	0.52	3.99	110	7.49
		End of Settling	8 hr	0.66	6.47	116	7.44

Date of Test: 3-19-97 Standards & Data AFFF Conc. = 30 ppm

Reactor	AFFF (ppm)	Stage	Time	Cl- Area	Cl- (mg/L)	NO_2^--N Area	NO_2^--N (mg/L)	NO_3^--N Area	NO_3^--N (mg/L)	PO_4^--P Area	PO_4^--P (mg/L)
		Feedstock		6749177618	265.7	0	0.0	3915995	0.0	467148802.0	23.1
		RR Decant		7663343044	301.7	0	0.0	5069557009	88.2	575236927	28.2
A1	0	End of Feeding	2 hr	7230717214	284.7	673542979	13.9	3971315101	69.2	626546248	30.6
		End of Anaerobic	4 hr	7233734632	284.8	672491596	13.9	3514232548	61.4	625368121	30.5
		End of Aerobic	6 hr	7339806534	289.0	0	0.0	4886149283	85.0	624533446	30.5
		End of Settling	8 hr	7431949728	292.6	0	0.0	4854649443	84.5	630967235	30.8
A2	0	End of Feeding	2 hr	7155799841	281.7	664639400	13.7	3879105112	67.7	618924049	30.2
		End of Anaerobic	4 hr	7254224048	285.6	676566742	14.0	3470590821	60.6	627413185	30.6
		End of Aerobic	6 hr	7239140382	285.0	0	0.0	4813571047	83.8	610728764	29.8
		End of Settling	8 hr	7449462899	293.3	0	0.0	4850523512	84.4	629108201	30.7
A3	0	End of Feeding	2 hr	7207850389	283.8	677025878	14.0	3776167668	65.9	638164525	31.1
		End of Anaerobic	4 hr	7206877106	283.7	771882496	16.1	3210866507	56.1	641605649	31.3
		End of Aerobic	6 hr	7349836882	289.3	0	0.0	4843685416	84.3	650582427	31.7
		End of Settling	8 hr	7451567532	293.3	0	0.0	4815586852	83.8	664668255	32.3
B1	30	End of Feeding	2 hr	7107431948	279.8	700450212	14.5	3637938056	63.5	614936829	30.0
		End of Anaerobic	4 hr	7164867497	282.1	705358770	14.6	2359480301	41.5	623776034	30.4
		End of Aerobic	6 hr	7216579405	284.1	94520525	1.1	4795762194	83.5	624629842	30.5
		End of Settling	8 hr	7339150068	288.9	104099755	1.3	4878811197	84.9	639704386	31.2
B2	30	End of Feeding	2 hr	7184445981	282.8	766307313	16.0	3520057758	61.5	639547580	31.2
		End of Anaerobic	4 hr	7233805315	284.8	775453906	16.2	3092634685	54.1	650229377	31.7
		End of Aerobic	6 hr	7236396592	284.9	131918031	2.0	4586108705	79.8	646921441	31.5
		End of Settling	8 hr	7245675200	285.2	133580697	2.0	4581669436	79.8	650434492	31.7
B3	30	End of Feeding	2 hr	7235111087	284.8	750425766	15.6	3631816543	63.4	643197222	31.3
		End of Anaerobic	4 hr	7299630260	287.4	748493552	15.6	3272948693	57.2	651549922	31.7
		End of Aerobic	6 hr	7353351797	289.5	0	0.0	4791555022	83.4	643591547	31.4
		End of Settling	8 hr	7412792736	292	0	0	4811431209	83.7	651429828	31.7
		Stand 2		5067875233	199.6	529076785	10.7	499892101	9.4	170171271	9.3
		Stand 3		6358700181	250.4	1021541138	21.6	1071884530	19.3	359982518	18.1
		Stand 4		7745289811	304.9	1836909059	39.6	2323294268	40.9	864357465	41.7
		DI Water		870226	0.0	64896	0.0	0	0.0	0	1.3
		Standards used									
		STD 1		0	0	0	0	0	0	0	0
		STD 2		5061991862	200	515381547	10	498927438	10	169167523	10
		STD 3		6312284856	250	1004700840	20	1067670730	20	367860964	20
		STD 4		7661395328	300	1820168589	40	2304799750	40	848926869	40

Date of Test: 3-19-97 | Standards & Data | AFFF Conc. = 30 ppm



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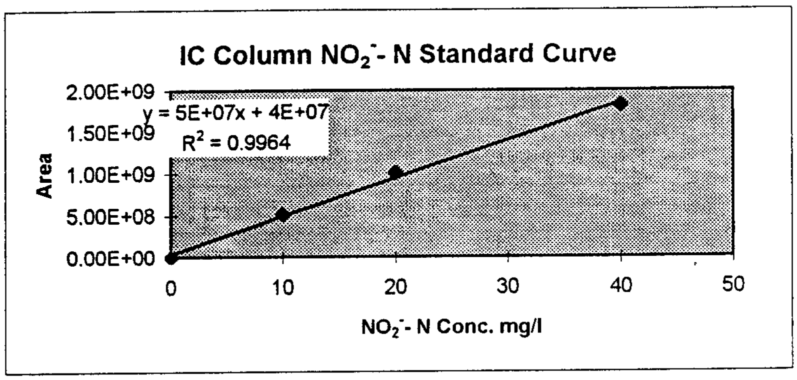

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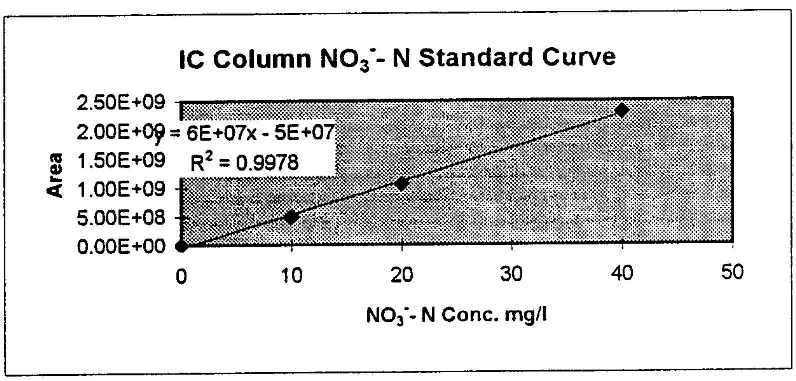

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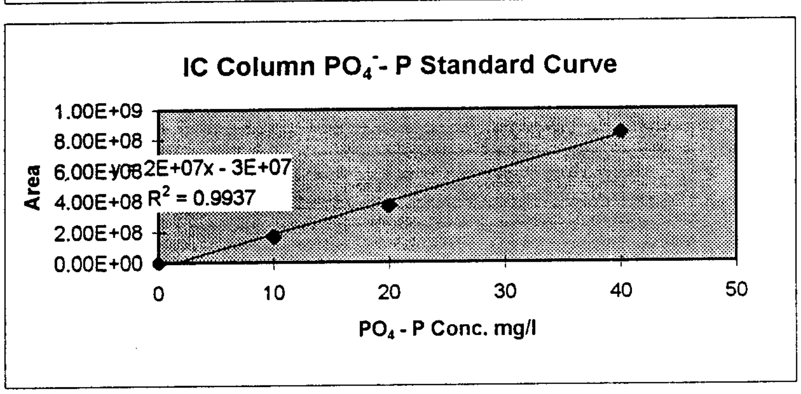


m = 21430572

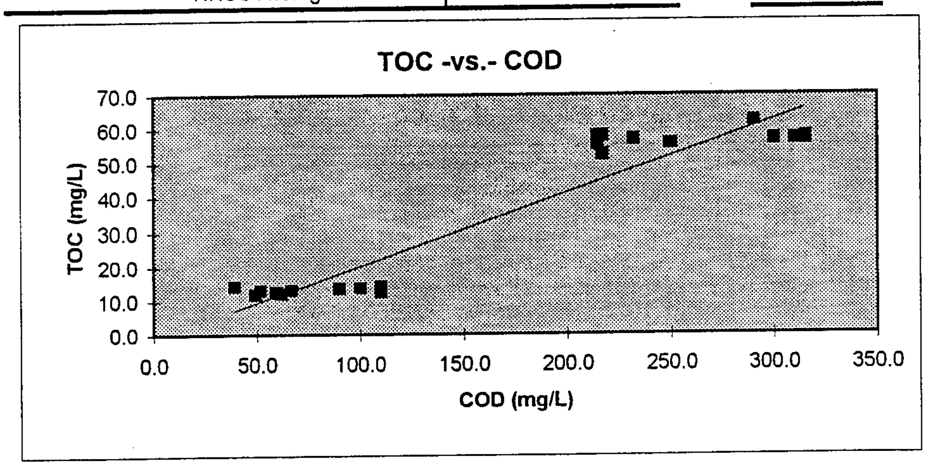
i = -2.9E+07

Date of Test: 3-19-97 | Concentrations Table | AFFF Conc. = 30 ppm

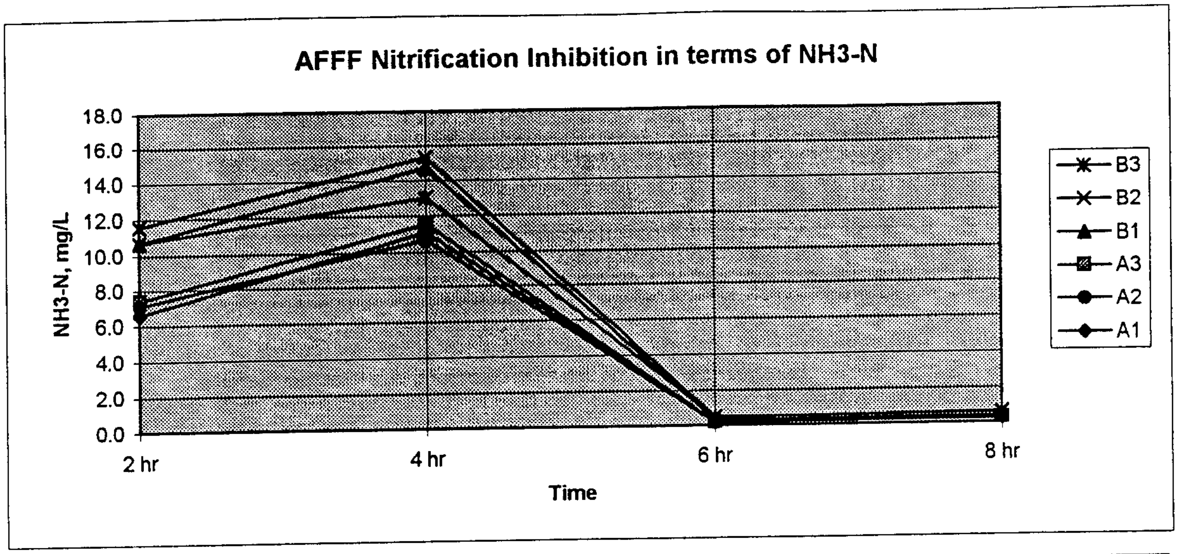
Reactor	AFFF (ppm)	Stage	Time	TKN	NH3-N	Org. N	NO2–N	NO3–N	Total N	Cl-	PO4-P
				Concentration, mg/L							
		Feedstock		413.9	35.7	378.1	0.0	0.0	413.9	265.7	23.1
		RR Decant		6.2	0.4	5.8	0.0	88.2	94.4	301.7	28.2
A1	0	End of Feeding	2 hr	14.6	6.6	8.0	13.9	69.2	97.8	284.7	30.6
		End of Anaerobic	4 hr	14.3	11.1	3.2	13.9	61.4	89.5	284.8	30.5
		End of Aerobic	6 hr	4.9	0.2	4.7	0.0	85.0	89.9	289.0	30.5
		End of Settling	8 hr	8.9	0.3	8.6	0.0	84.5	93.4	292.6	30.8
A2	0	End of Feeding	2 hr	20.8	7.1	13.7	13.7	67.7	102.2	281.7	30.2
		End of Anaerobic	4 hr	13.9	10.7	3.3	14.0	60.6	88.5	285.6	30.6
		End of Aerobic	6 hr	7.3	0.2	7.1	0.0	83.8	91.1	285.0	29.8
		End of Settling	8 hr	5.1	0.3	4.8	0.0	84.4	89.5	293.3	30.7
A3	0	End of Feeding	2 hr	15.7	7.4	8.3	14.0	65.9	95.6	283.8	31.1
		End of Anaerobic	4 hr	12.3	11.6	0.8	16.1	56.1	84.6	283.7	31.3
		End of Aerobic	6 hr	4.9	0.2	4.7	0.0	84.3	89.2	289.3	31.7
		End of Settling	8 hr	5.5	0.3	5.2	0.0	83.8	89.3	293.3	32.3
B1	30	End of Feeding	2 hr	19.2	10.7	8.6	14.5	63.5	97.2	279.8	30.0
		End of Anaerobic	4 hr	19.8	14.7	5.1	14.6	41.5	75.9	282.1	30.4
		End of Aerobic	6 hr	5.3	0.3	5.0	1.1	83.5	89.9	284.1	30.5
		End of Settling	8 hr	5.7	0.4	5.3	1.3	84.9	92.0	288.9	31.2
B2	30	End of Feeding	2 hr	22.6	11.6	11.0	16.0	61.5	100.0	282.8	31.2
		End of Anaerobic	4 hr	25.5	15.3	10.2	16.2	54.1	95.8	284.8	31.7
		End of Aerobic	6 hr	9.3	0.5	8.8	2.0	79.8	91.1	284.9	31.5
		End of Settling	8 hr	3.0	0.7	2.3	2.0	79.8	84.8	285.2	31.7
B3	30	End of Feeding	2 hr	20.0	10.7	9.4	15.6	63.4	99.0	284.8	31.3
		End of Anaerobic	4 hr	22.5	13.0	9.5	15.6	57.2	95.3	287.4	31.7
		End of Aerobic	6 hr	4.0	0.5	3.5	0.0	83.4	87.4	289.5	31.4
		End of Settling	8 hr	6.5	0.7	5.8	0.0	83.7	90.2	291.8	31.7

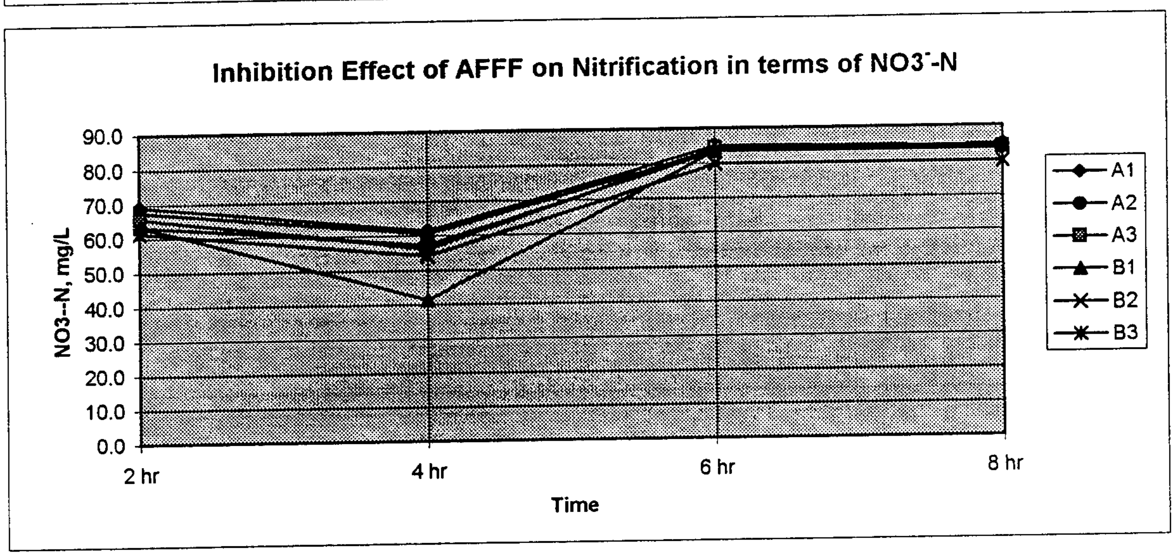
Date of Test: 3-19-97 | Concentrations Table | AFFF Conc. = 30 ppm

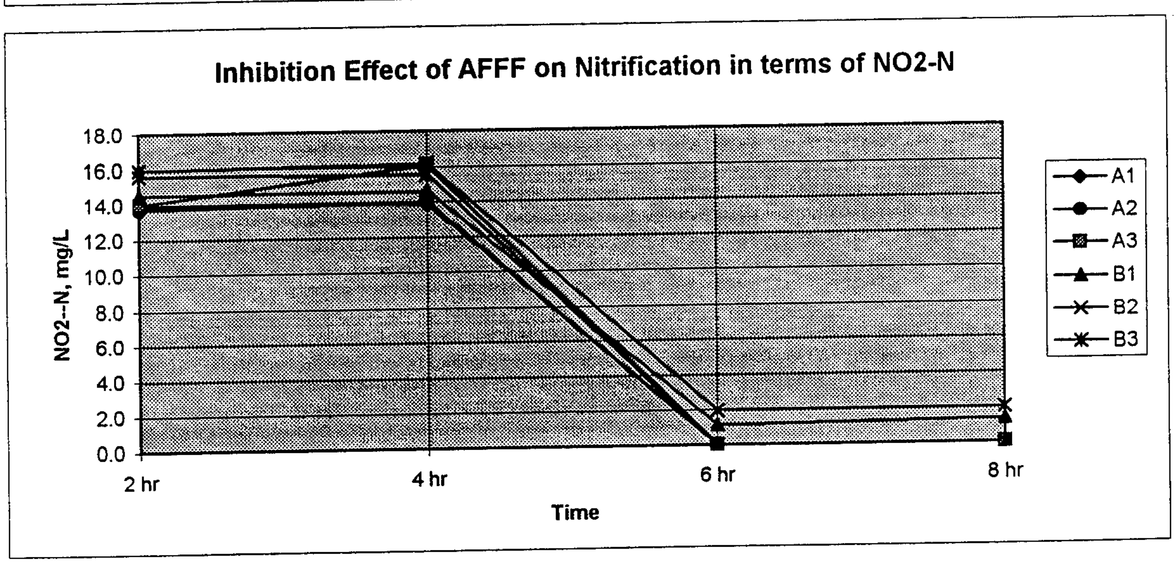
Reactor	AFFF (ppm)	Stage	Time	Concentration, mg/L COD	Concentration, mg/L TOC	Alkalinity HCO3 (mg/l)
		Feedstock		1337.5	**391.2**	318
		RR Decant		95.0	**13.6**	224
A1	0	End of Feeding	2 hr	90.0	**13.6**	204.5
		End of Anaerobic	4 hr	100.0	**13.9**	202
		End of Aerobic	6 hr	39.3	**14.4**	215
		End of Settling	8 hr	66.8	**13.3**	220.5
A2	0	End of Feeding	2 hr	110.0	**13.2**	177
		End of Anaerobic	4 hr	110.0	**12.6**	204
		End of Aerobic	6 hr	49.3	**11.9**	164
		End of Settling	8 hr	61.8	**12.2**	162.5
A3	0	End of Feeding	2 hr	110.0	**14.2**	168.5
		End of Anaerobic	4 hr	110.0	**13.9**	192
		End of Aerobic	6 hr	59.3	**12.6**	136.5
		End of Settling	8 hr	51.8	**13.0**	173
B1	30	End of Feeding	2 hr	290.0	**62.2**	207
		End of Anaerobic	4 hr	310.0	**57.2**	204.5
		End of Aerobic	6 hr	214.3	**57.9**	129
		End of Settling	8 hr	231.8	**56.8**	133
B2	30	End of Feeding	2 hr	300.0	**56.9**	195.5
		End of Anaerobic	4 hr	315.0	**56.9**	198
		End of Aerobic	6 hr	216.8	**58.1**	126
		End of Settling	8 hr	249.3	**55.6**	126.5
B3	30	End of Feeding	2 hr	250.0	**55.6**	185
		End of Anaerobic	4 hr	315.0	**57.6**	201
		End of Aerobic	6 hr	214.3	**55.4**	133
		End of Settling	8 hr	216.8	**52.4**	132.5
		FS1			392.5	
		FS2			389.4	
		FS3			391.8	
		FS Avarage			391.2	
		RRSU1			13.8	
		RRSU2			13.6	
		RRSU3			13.3	
		RRSU Avarage			13.57	



Date of Test: 3-19-97 NH3-N & TKN Charts AFFF Conc. = 30 ppm



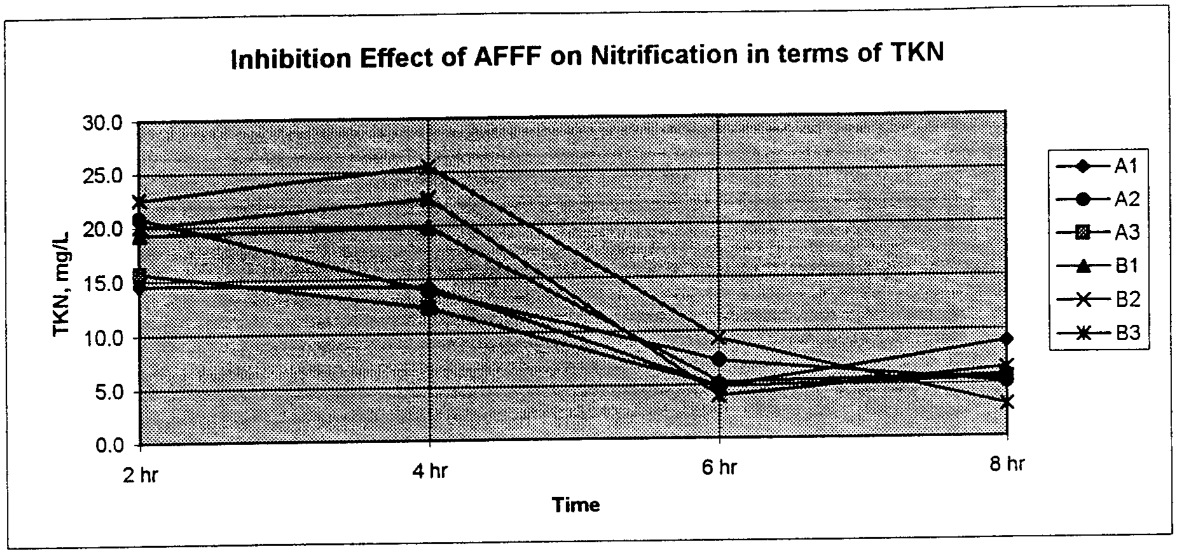




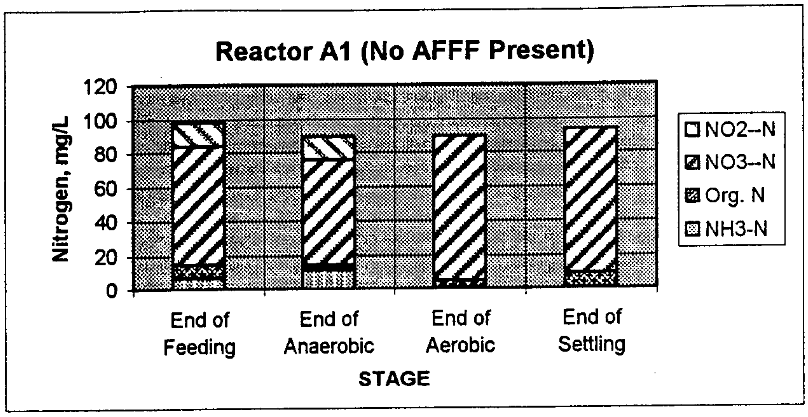
Date of Test: 3-19-97

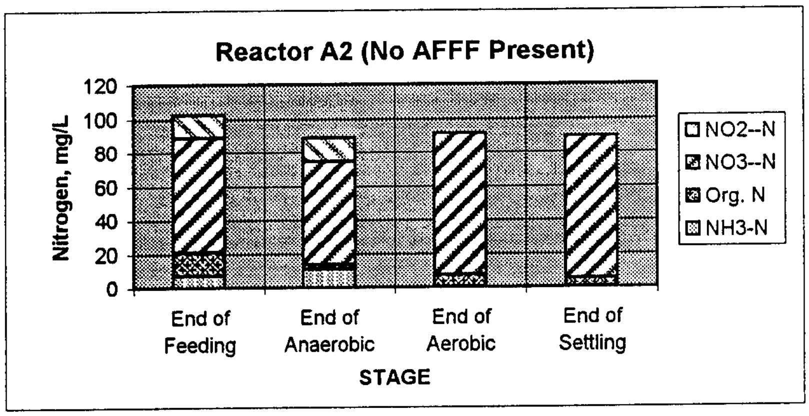
NH3-N & TKN Charts

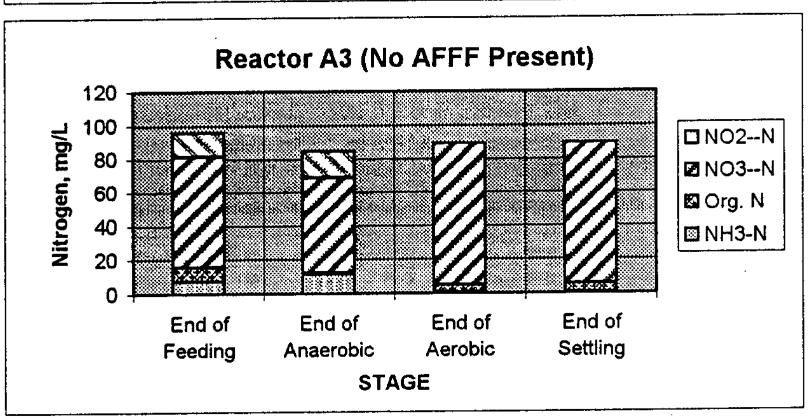
AFFF Conc. = 30 ppm



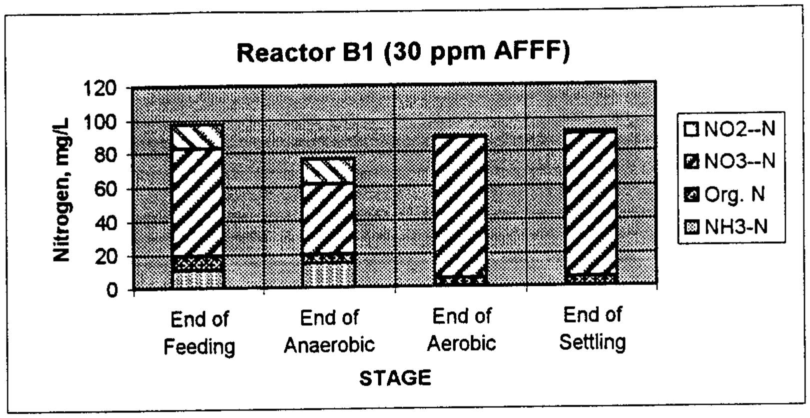
Date of Test: 3-19-97 Inhibition Reactors / Nitrogen Mass Balance AFFF Conc. = 30 ppm

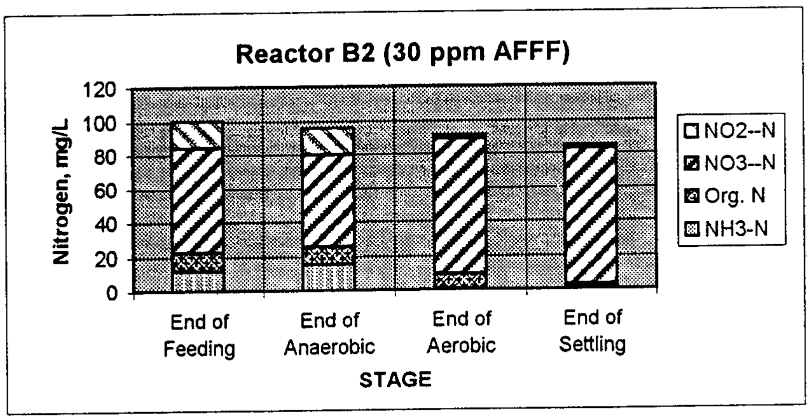


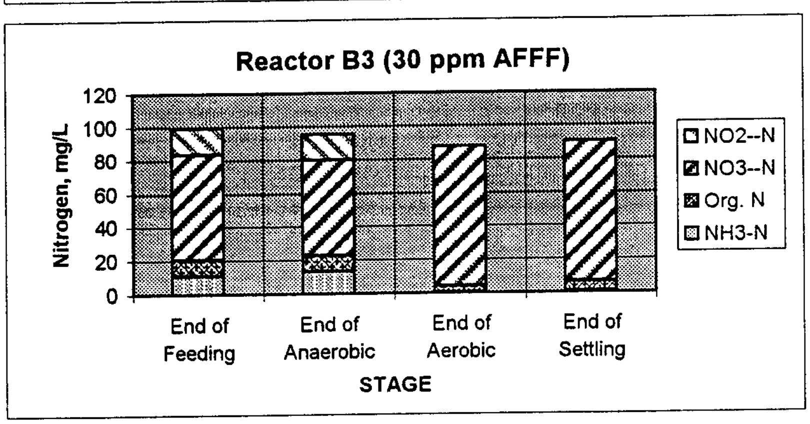




Date of Test: 3-19-97 | Inhibition Reactors / Nitrogen Mass Balance | AFFF Conc. = 30 ppm

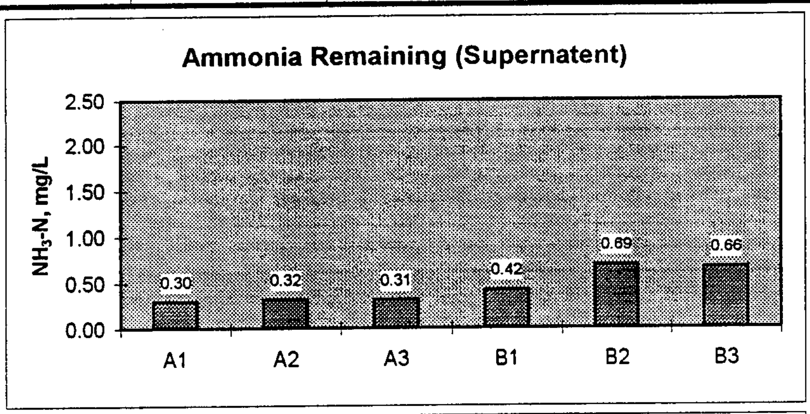


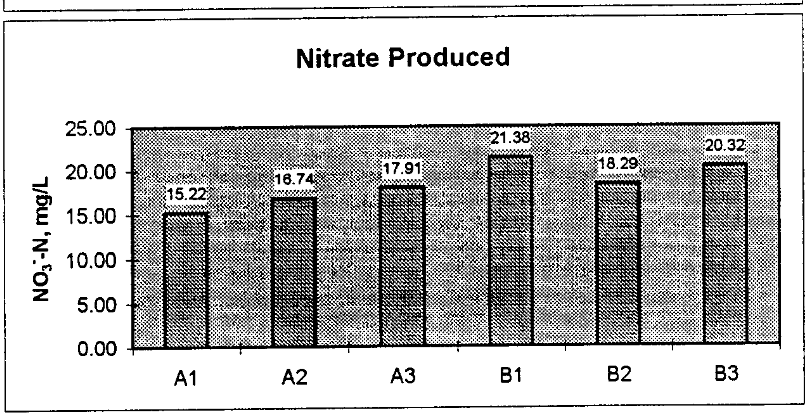




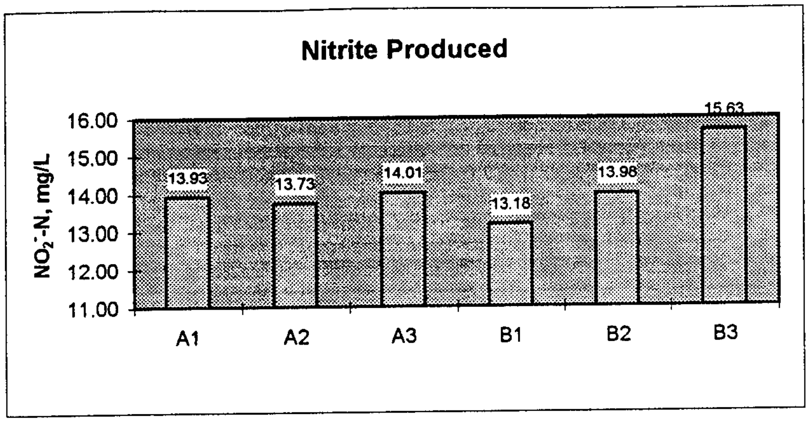
Date of Test: 3-19-97 | Inhibition Reactors / NO3- & NO2 Produced | AFFF Conc. = 30 ppm

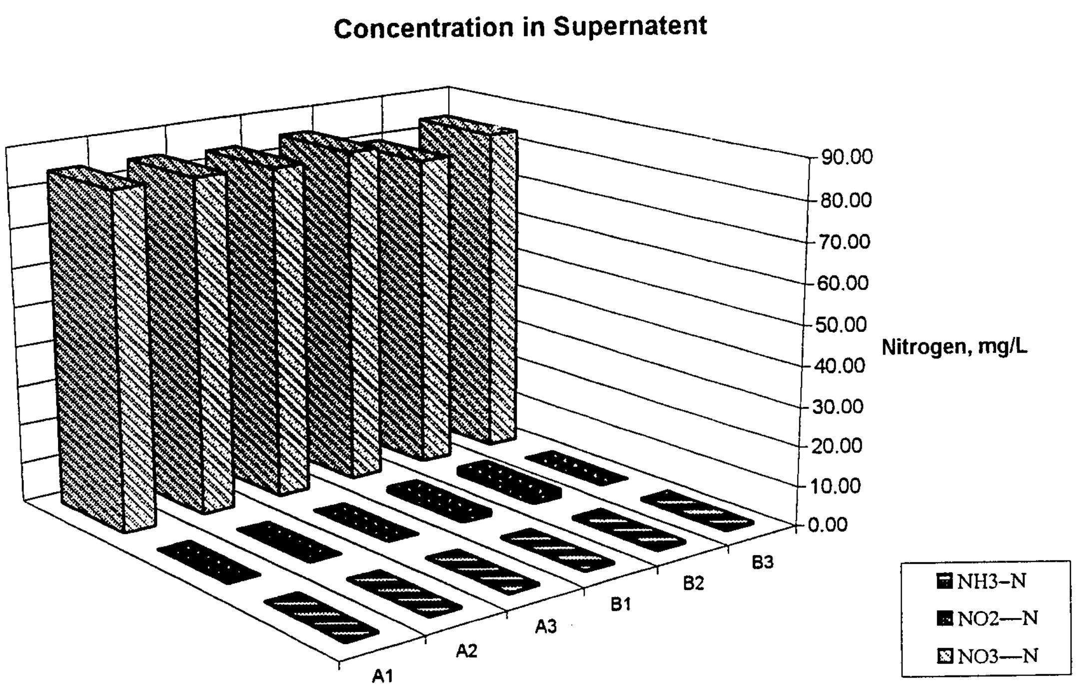
Reactor	AFFF ppm	Stage	Time	NH3-N	NO3--N	NO2--N	$\Delta(NO_3^-$-N)	$\Delta(NO_2$-N)
				Nitrogen Concentration, mg/L				
A1	0	End of Feeding	2 hr	6.57	69.2	13.9		
(Control)		End of Anaerobic	4 hr	11.10	61.4	13.9		
		End of Aerobic	6 hr	0.21	85.0	0.0		
		End of Settling	8 hr	0.30	84.5	0.0	15.22	13.93
A2	0	End of Feeding	2 hr	7.13	67.7	13.7		
(Control)		End of Anaerobic	4 hr	10.66	60.6	14.0		
		End of Aerobic	6 hr	0.19	83.8	0.0		
		End of Settling	8 hr	0.32	84.4	0.0	16.74	13.73
A3	0	End of Feeding	2 hr	7.42	65.9	14.0		
(Control)		End of Anaerobic	4 hr	11.56	56.1	16.1		
		End of Aerobic	6 hr	0.23	84.3	0.0		
		End of Settling	8 hr	0.31	83.8	0.0	17.91	14.01
B1	30	End of Feeding	2 hr	10.66	63.5	14.5		
		End of Anaerobic	4 hr	14.72	41.5	14.6		
		End of Aerobic	6 hr	0.33	83.5	1.1		
		End of Settling	8 hr	0.42	84.9	1.3	21.38	13.18
B2	30	End of Feeding	2 hr	11.56	61.5	16.0		
		End of Anaerobic	4 hr	15.32	54.1	16.2		
		End of Aerobic	6 hr	0.50	79.8	2.0		
		End of Settling	8 hr	0.69	79.8	2.0	18.29	13.98
B3	30	End of Feeding	2 hr	10.66	63.4	15.6		
		End of Anaerobic	4 hr	13.04	57.2	15.6		
		End of Aerobic	6 hr	0.52	83.4	0.0		
		End of Settling	8 hr	0.66	83.7	0.0	20.32	15.63





Date of Test: 3-19-97 Inhibition Reactors / NO3- & NO2 Produced AFFF Conc. = 30 ppm



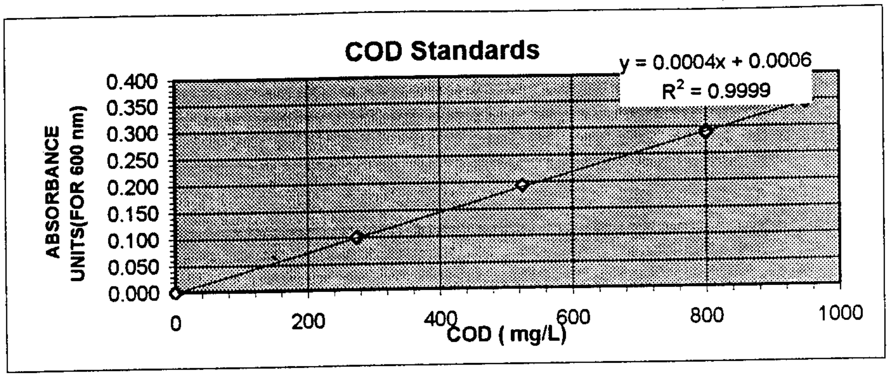


Date of Test: 3-19-97 COD Concentration and Removal % AFFF Conc. = 30 ppm

Reactor	AFFF (ppm)	Stage	Time	ABS	COD *** (mg/L)	% COD Removal
		Feedstock			**1337.5**	
		RR Decant			**95.0**	
A1	0	End of Feeding	2 hr		**90.0**	82.3
		End of Anaerobic	4 hr		**100.0**	80.4
		End of Aerobic	6 hr		**39.3**	92.3
		End of Settling	8 hr		**66.8**	**86.9**
A2	0	End of Feeding	2 hr		**110.0**	78.4
		End of Anaerobic	4 hr		**110.0**	78.4
		End of Aerobic	6 hr		**49.3**	90.3
		End of Settling	8 hr		**61.8**	**87.9**
A3	0	End of Feeding	2 hr		**110.0**	78.4
		End of Anaerobic	4 hr		**110.0**	78.4
		End of Aerobic	6 hr		**59.3**	88.4
		End of Settling	8 hr		**51.8**	**89.8**
B1	30	End of Feeding	2 hr		**290.0**	69.4
		End of Anaerobic	4 hr		**310.0**	67.3
		End of Aerobic	6 hr		**214.3**	77.4
		End of Settling	8 hr		**231.8**	**75.5**
B2	30	End of Feeding	2 hr		**300.0**	68.3
		End of Anaerobic	4 hr		**315.0**	66.8
		End of Aerobic	6 hr		**216.8**	77.1
		End of Settling	8 hr		**249.3**	**73.7**
B3	30	End of Feeding	2 hr		**250.0**	73.6
		End of Anaerobic	4 hr		**315.0**	66.8
		End of Aerobic	6 hr		**214.3**	77.4
		End of Settling	8 hr		**216.8**	**77.1**
		STD 1		0.000	0	
		STD 2		0.100	275	
		STD 3		0.193	525	
		STD 4		0.289	800	
		STD 5		0.345	950	
		FS1			1325.0	
		FS2			1350.0	
		FS Average			1337.5	
		RRSU1			90.0	
		RRSU2			100.0	
		RRSU Average			95.0	

*** COD was obtained by using HACH test rather than BioScience as usual (3/19/97).

Date of Test: 3-19-97 | COD Concentration and Removal % | AFFF Conc. = 30 ppm



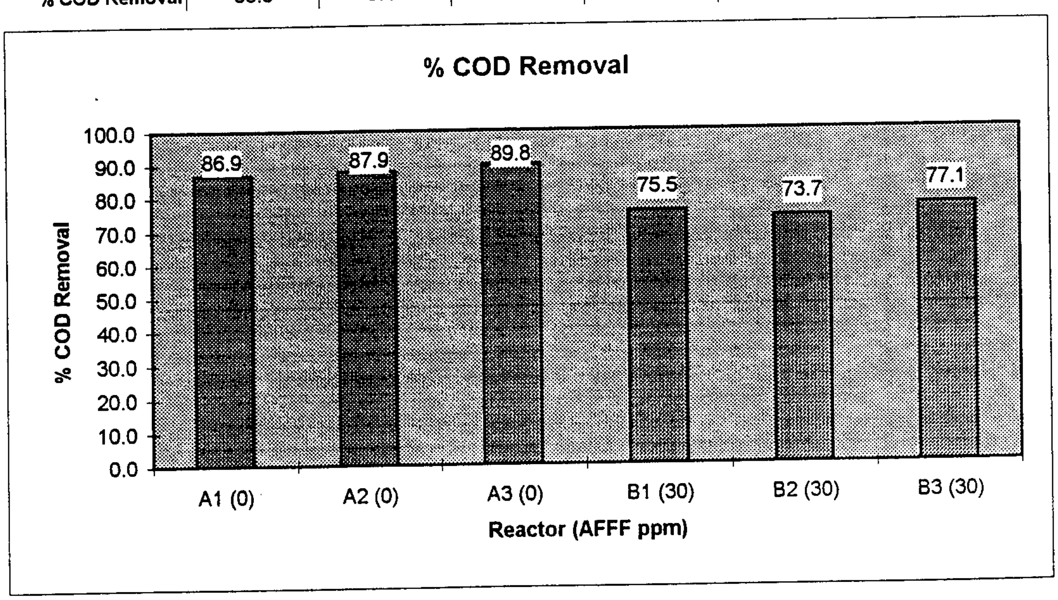
m = *0.0004*

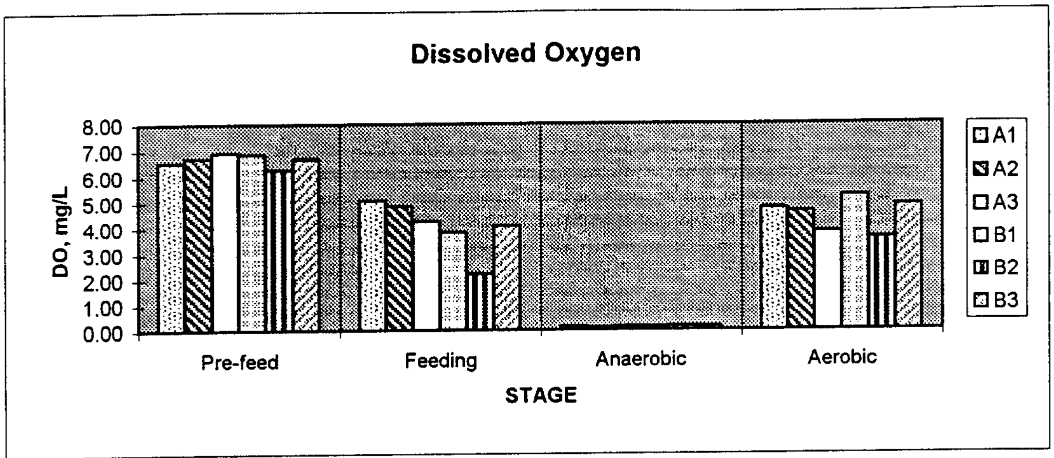
i = *0.0006*

Initial COD

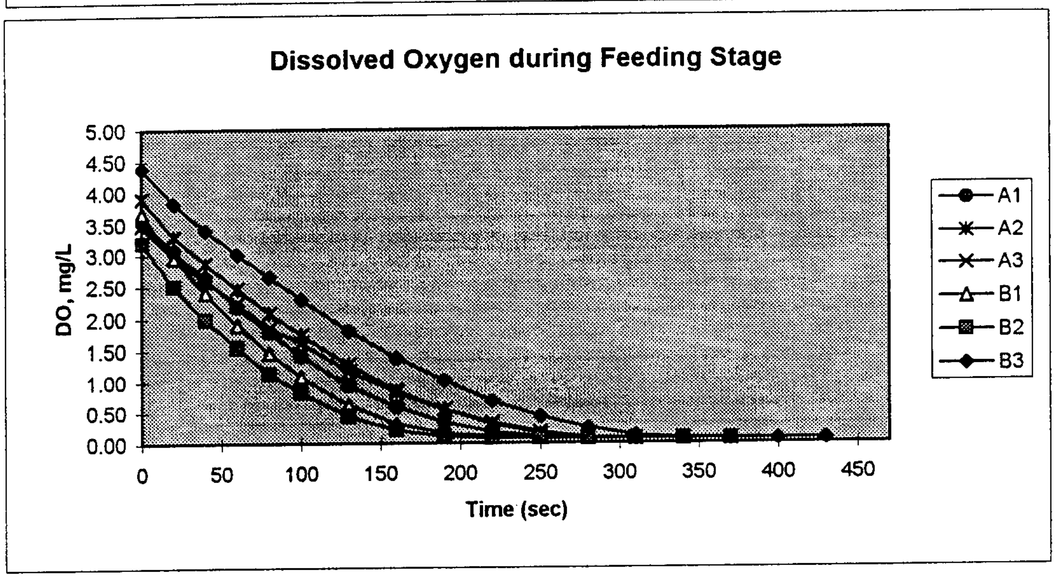
Sample	Const	Vol (L)	COD mg/L	(AFFF +Feed) COD mg/l
Controls	RR Decant	4	95	380
(A1,A2&A3)	Feedstock	2	1337.5	2675
	AFFF	0	0	0
	Total	6		**509.2**
Inhibition	RR Decant	4	95	380
(B1,B2&B3)	Feedstock	2	1337.5	2675
	AFFF	2	1315	2630
	Total	6		**947.5**

Reactor (AFFF ppm)	A1 (0)	A2 (0)	A3 (0)	B1 (30)	B2 (30)	B3 (30)
% COD Removal	86.9	87.9	89.8	75.5	73.7	77.1

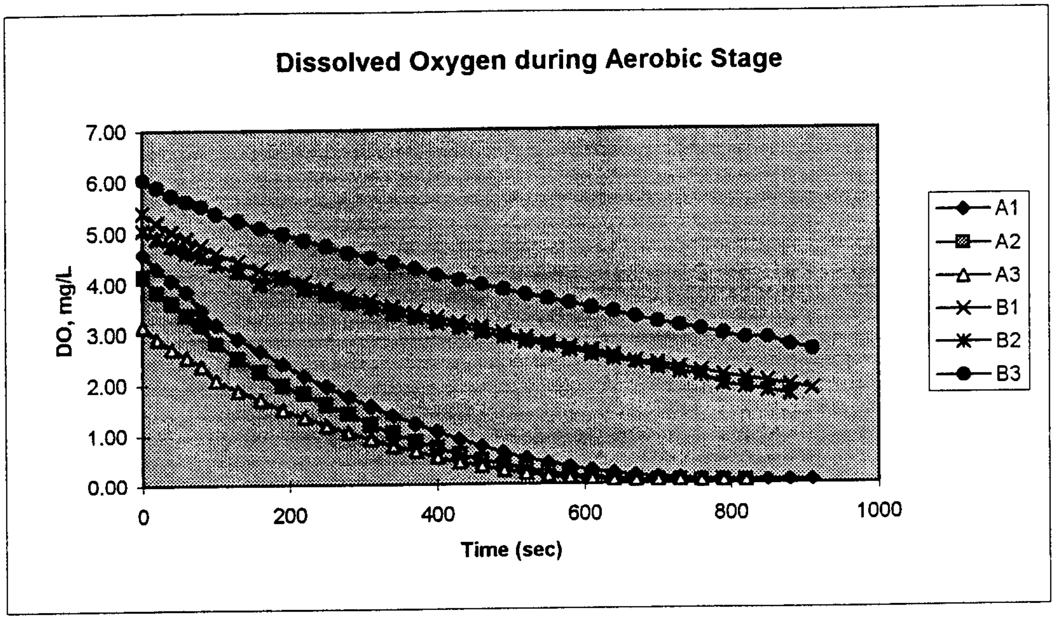




Dissolved Oxygen
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
DO, mg/L
Pre-feed
Feeding
Anaerobic
Aerobic
STAGE
A1
A2
A3
B1
B2
B3

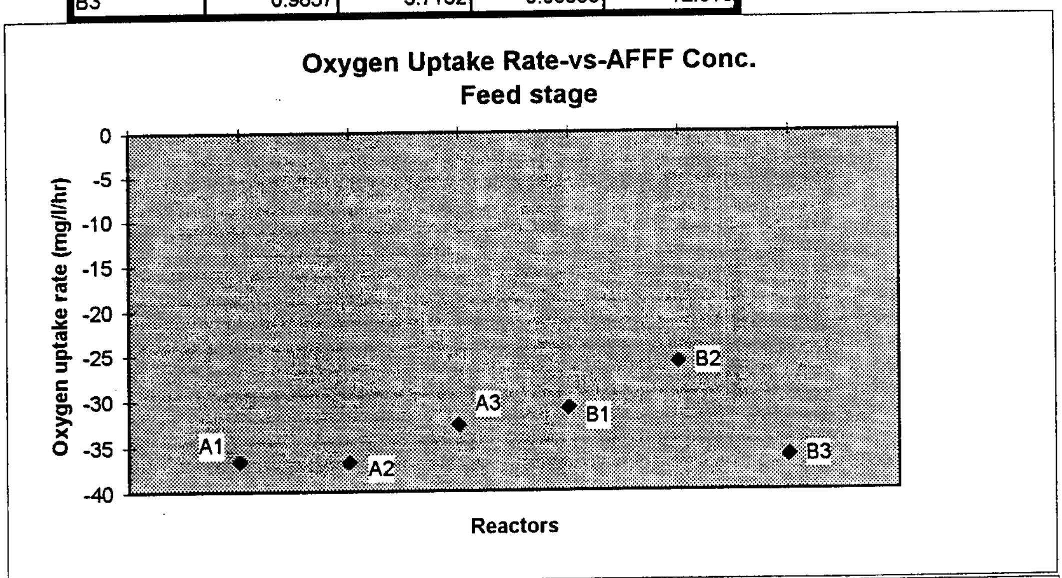


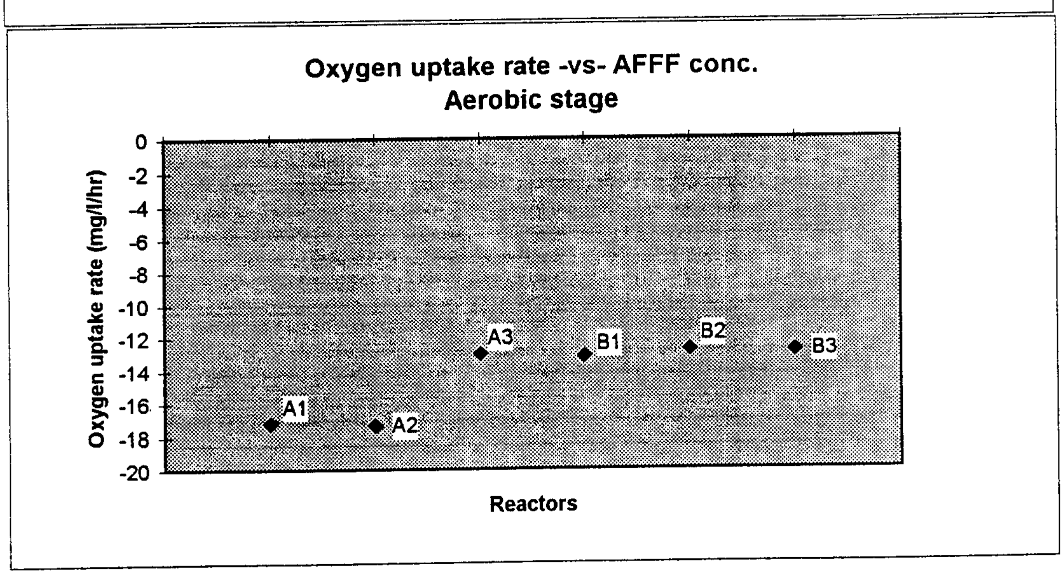
Dissolved Oxygen during Feeding Stage
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
DO, mg/L
0
50
100
150
200
250
300
350
400
450
Time (sec)
A1
A2
A3
B1
B2
B3


Dissolved Oxygen during Aerobic Stage
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
DO, mg/L
0
200
400
600
800
1000
Time (sec)
A1
A2
A3
B1
B2
B3

Regression Summary

		Feed stage		
Samples	R square	Intercept	Slopemg/l/sec	Slopemg/l/hr
A1	0.854275	2.7973	-0.01016	-36.576
A2	0.868	3.054	-0.0102	-36.72
A3	0.8784	2.752	-0.00909	-32.724
B1	0.7438	2.465	-0.00858	-30.888
B2	0.71	2.04477	-0.00717	-25.812
B3	0.8836	3.4976	-0.01003	-36.108
		Aerobic Stage		
Samples	R square	Intercept	Slopemg/l/sec	Slopemg/l/hr
A1	0.875	3.517673746	-0.00477679	-17.1964603
A2	0.8722	3.1826	-0.00481	-17.316
A3	0.8681	2.3953	-0.00361	-12.996
B1	0.9736	4.9397	-0.00365	-13.14
B2	0.986	4.7427	-0.00354	-12.744
B3	0.9857	5.7152	-0.00356	-12.816





SOUR CALCULATIONS

			Feed stage			Aerobic stage	
AFFF (ppm)	Samples	slope(mg/l/hr)	slope(mg/l/hr/VSS)		slope(mg/l/hr)	slope(mg/l/hr/VSS)	
0	A1	-36.576	-0.01422		-17.1965	-0.00668	
0	A2	-36.72	-0.01601		-17.316	-0.00755	
0	A3	-32.724	-0.01189		-12.996	-0.00472	
30	B1	-30.888	-0.01603		-13.14	-0.00682	
30	B2	-25.812	-0.01122		-12.744	-0.00554	
30	B3	-36.108	-0.01647		-12.816	-0.00584	

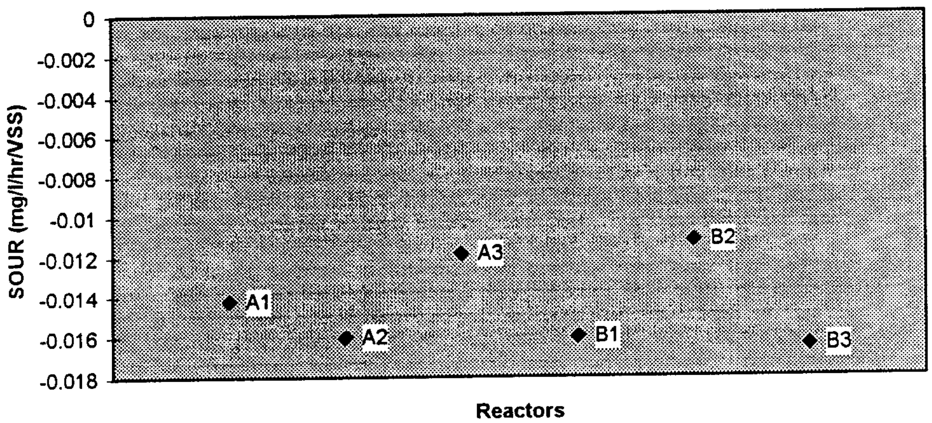


Figure 3-4: Specific Oxygen uptake rates (SOUR's) during the feed stage for 30 ppm AFFF (A--Control, B--Inhibition)

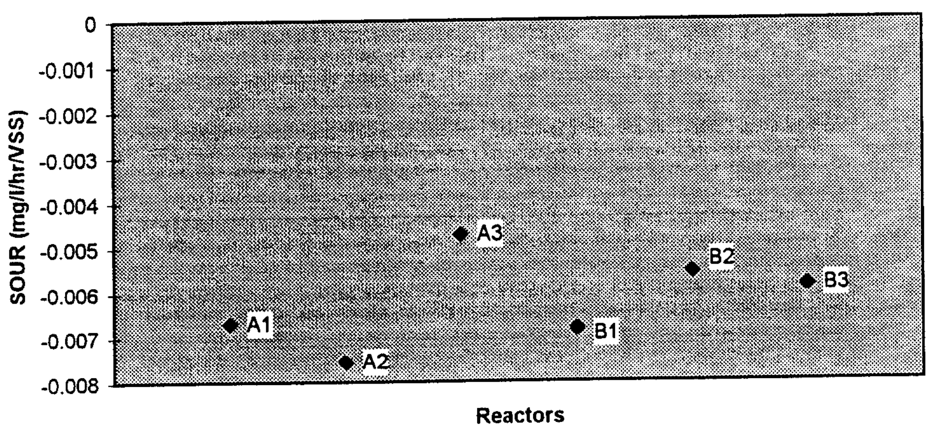


Figure 3-5: Specific Oxygen uptake rates (SOUR's) during the aerobic stage for 30 ppm AFFF (A--Control, B--Inhibition

Date of Test: 3-19-97

AFFF Conc. = 30 ppm

Time (hr)	Stage	Dissolved Oxygen (mg/L) at various stages A1	A2	A3	B1	B2	B3
	Pre-feed	6.53	6.70	6.90	6.84	6.28	6.68
0:00	Feeding	5.08	4.85	4.28	3.83	2.18	4.07
3:00	Anaerobic	0.13	0.11	0.12	0.13	0.14	0.14
4:15	Aerobic	4.77	4.65	3.82	5.24	3.60	4.89

Oxygen Uptake Rate

		Dissolved Oxygen in mg/L					
Stage	Time (sec)	A1	A2	A3	B1	B2	B3
Feeding	0	3.56	3.91	3.49	3.68	3.20	4.39
	20	3.06	3.31	2.96	2.95	2.50	3.83
	40	2.63	2.86	2.58	2.40	1.98	3.41
	60	2.18	2.46	2.23	1.90	1.54	3.01
	80	1.78	2.09	1.84	1.46	1.13	2.65
	100	1.41	1.74	1.62	1.08	0.83	2.30
	130	0.94	1.28	1.17	0.63	0.44	1.80
	160	0.59	0.86	0.84	0.32	0.21	1.38
	190	0.34	0.55	0.54	0.16	0.11	1.02
	220	0.18	0.31	0.34	0.11	0.08	0.69
	250	0.11	0.15	0.18	0.09	0.08	0.43
	280	0.08	0.08	0.09	0.09	0.07	0.25
	310	0.08	0.07	0.07	0.08	0.07	0.12
	340	0.08	0.07	0.07	0.08	0.07	0.08
	370		0.07	0.07	0.08	0.07	0.07
	400						0.07
	430						0.07

Date of Test: 3-19-97

AFFF Conc. = 30 ppm

Stage	Time (sec)	Dissolved Oxygen in mg/L					
		A1	A2	A3	B1	B2	B3
Aerobic	0	4.58	4.15	3.15	5.39	5.05	6.04
	20	4.31	3.82	2.90	5.20	4.89	5.89
	40	4.07	3.61	2.71	5.02	4.75	5.72
	60	3.84	3.37	2.54	4.88	4.63	5.61
	80	3.46	3.17	2.37	4.76	4.53	5.51
	100	3.18	2.80	2.09	4.60	4.38	5.36
	130	2.91	2.50	1.88	4.43	4.25	5.23
	160	2.66	2.25	1.70	4.28	4.00	5.09
	190	2.41	1.96	1.50	4.15	4.12	4.97
	220	2.17	1.81	1.35	4.02	3.88	4.85
	250	1.96	1.59	1.19	3.88	3.77	4.73
	280	1.75	1.41	1.05	3.75	3.61	4.60
	310	1.57	1.20	0.91	3.64	3.51	4.50
	340	1.38	1.03	0.78	3.52	3.39	4.39
	370	1.21	0.87	0.67	3.41	3.31	4.28
	400	1.06	0.74	0.55	3.30	3.21	4.16
	430	0.90	0.60	0.45	3.21	3.11	4.06
	460	0.76	0.49	0.37	3.10	3.02	3.96
	490	0.64	0.40	0.29	3.01	2.92	3.86
	520	0.53	0.31	0.23	2.91	2.82	3.76
	550	0.44	0.24	0.18	2.82	2.74	3.67
	580	0.35	0.19	0.14	2.72	2.65	3.58
	610	0.28	0.15	0.11	2.64	2.57	3.48
	640	0.23	0.12	0.09	2.55	2.48	3.40
	670	0.18	0.09	0.08	2.43	2.40	3.30
	700	0.15	0.08	0.07	2.39	2.31	3.21
	730	0.12	0.07	0.07	2.31	2.22	3.13
	760	0.10	0.06	0.06	2.24	2.15	3.05
	790	0.09	0.06	0.06	2.16	1.97	2.97
	820	0.08	0.06	0.06	2.09	1.92	2.88
	850	0.07			2.03	1.84	2.88
	880	0.07			1.95	1.77	2.73
	910	0.07			1.88		2.64

Regression Summary

		Feed stage				Aerobic Stage		
Samples	R square	Intercept	Slopemg/l/sec	Slopemg/l/hr	R square	Intercept	Slopemg/l/sec	Slopemg/l/hr
A1	0.854275	2.7973	-0.01016	-36.576	0.875	3.517673746	-0.00477679	-17.1964603
A2	0.868	3.054	-0.0102	-36.72	0.8722	3.1826	-0.00481	-17.316
A3	0.8784	2.752	-0.00909	-32.724	0.8681	2.3953	-0.00361	-12.996
B1	0.7438	2.465	-0.00858	-30.888	0.9736	4.9397	-0.00365	-13.14
B2	0.71	2.04477	-0.00717	-25.812	0.986	4.7427	-0.00354	-12.744
B3	0.8836	3.4976	-0.01003	-36.108	0.9857	5.7152	-0.00356	-12.816

Date of Test: 3-19-97 BOD$_5$ of Inhibition Run AFFF Conc. = 30 ppm

Date, initial: 3/19/97 Date, final: 3/24/97

	Time 2 hr						
Bottle No.	53	777	555	187	109	171	Remarks
Sample Location	A1	A2	A3	B1	B2	B3	
% Sample in BOD Bottle	19.3%	25.0%	25.0%	25.0%	25.0%	25.0%	
Initial D.O. (mg/L)	8.04	8.02	8.02	8.00	8.01	8.01	
Final D.O. (mg/L)	6.81	6.74	6.89	0.21	0.15	0.13	Note 4
D.O. Depletion	1.23	1.28	1.13	7.79	7.86	7.88	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	0.7	0.7	0.7	0.7	0.7	0.7	
BOD of Sample	3	2	2	28	29	29	
Average BOD (mg/L)		2			29		

	Time 4 hr						
Bottle No.	114	230	70	48	111	68	Remarks
Sample Location	A1	A2	A3	B1	B2	B3	
% Sample in BOD Bottle	25.0%	25.0%	25.0%	25.0%	25.0%	16.7%	
Initial D.O. (mg/L)	7.92	7.92	8.01	7.80	7.81	7.96	
Final D.O. (mg/L)	6.56	6.81	6.77	0.18	0.23	0.15	Note 4
D.O. Depletion	1.36	1.11	1.24	7.62	7.58	7.81	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	0.7	0.7	0.7	0.7	0.7	0.7	
BOD of Sample	3	2	2	28	27	43	
Average BOD (mg/L)		2			33		

	Time 6 hr						
Bottle No.	19	666	L6	108	10	268	Remarks
Sample Location	A1	A2	A3	B1	B2	B3	
% Sample in BOD Bottle	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	
Initial D.O. (mg/L)	7.84	7.82	7.82	7.72	7.72	7.65	
Final D.O. (mg/L)	6.82	6.83	6.79	0.10	0.11	0.11	Note 4
D.O. Depletion	1.02	0.99	1.03	7.62	7.61	7.54	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	0.7	0.7	0.7	0.7	0.7	0.7	
BOD of Sample	1	1	1	28	28	27	
Average BOD (mg/L)		1			28		

	Time 8 hr						
Bottle No.	268	999	108	187	666	53	Remarks
Sample Location	A1	A2	A3	B1	B2	B3	
% Sample in BOD Bottle	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%	
Initial D.O. (mg/L)	7.61	7.54	7.45	7.40	7.75	7.54	
Final D.O. (mg/L)	6.45	6.57	6.24	0.11	0.11	0.11	Note 4
D.O. Depletion	1.16	0.97	1.21	7.29	7.64	7.43	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	0.7	0.7	0.7	0.7	0.7	0.7	
BOD of Sample	2	1	2	26	28	27	
Average BOD (mg/L)		2			27		

Bottle No.	103	56	22	"Seed"	G/G #1	G/G #2	Blank	
Sample Location	Seed Control	Seed Control	Seed Control	Average	G/G Acid #1	G/G Acid #2	Blank	Remarks
% Sample in BOD Bottle	-	-	-	-	2.0%	2.0%	100.0%	
Initial D.O. (mg/L)	8.00	8.00	7.98	-	7.97	8.02	8.03	
Final D.O. (mg/L)	7.21	7.35	7.30	-	4.45	4.20	7.69	
D.O. Depletion	0.79	0.65	0.68	0.7	3.52	3.82	0.34	Notes 1 & 2
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	-	Note 3
Seed Correction	-	-	-	-	0.7	0.7	-	Note 6
BOD of Sample (mg/L)	79	65	68	71	141	156	0.34	

Bottle No.	3	23	65	75	14	64	Remarks
Sample Location	Feedstock	Feedstock	Feedstock	RRSU	RRSU	RRSU	
% Sample in BOD Bottle	0.5%	0.5%	0.5%	50.0%	50.0%	13.3%	
Initial D.O. (mg/L)	7.99	7.97	7.99	7.70	7.65	8.06	
Final D.O. (mg/L)	3.75	4.25	4.45	6.65	6.40	6.69	Note 4
D.O. Depletion	4.24	3.72	3.54	1.05	1.25	1.37	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	0.7	0.7	0.7	0.7	0.7	0.7	
BOD of Sample (mg/L)	707	603	567	1	1	5	
Average BOD (mg/L)		625			2		

Notes:

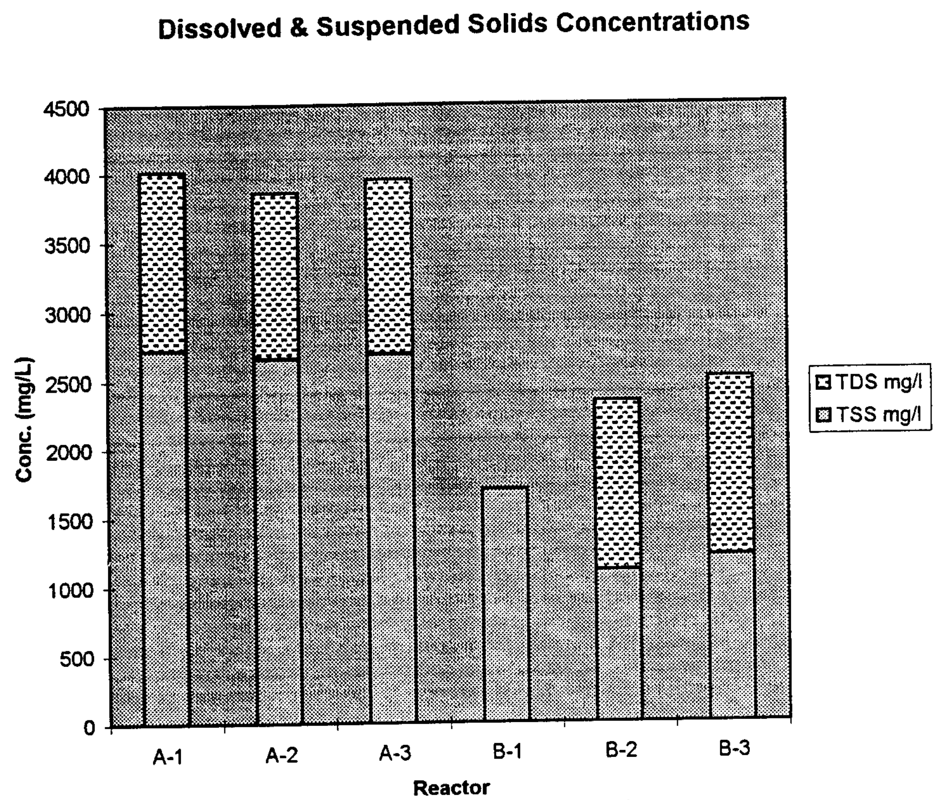
1 As per Standard Methods, the Seed Control DO depletion must be between 0.6 and 1.0 mg/L
2. For the Blank, the DO depletion should not be greater than 0.2 mg/L, and preferably not greater than 0.1 mg/L
3. Seed was prepared with 100mL of filtered decant from ref. reactor (collected @ 10am), 100mL of Dilution water, and one Polyseed capsule.
4 The residual DO of samples should be equal or greater than 1 mg/L.
5. The DO depletion of samples should be equal or greater than 2 mg/L.
6. The BOD of Glucose/Glutamic acid should be between 198 + or - 30.5 mg/L.

Reactor	AFFF (ppm)	Stage	Time	BOD5
		Feedstock		625
		RR Decant		2
A1	0	End of Feeding	2 hr	3
		End of Anaerobic	4 hr	3
		End of Aerobic	6 hr	1
		End of Settling	8 hr	2
A2	0	End of Feeding	2 hr	2
		End of Anaerobic	4 hr	2
		End of Aerobic	6 hr	1
		End of Settling	8 hr	1
A3	0	End of Feeding	2 hr	2
		End of Anaerobic	4 hr	2
		End of Aerobic	6 hr	1
		End of Settling	8 hr	2
B1	30	End of Feeding	2 hr	28
		End of Anaerobic	4 hr	28
		End of Aerobic	6 hr	28
		End of Settling	8 hr	26
B2	30	End of Feeding	2 hr	29
		End of Anaerobic	4 hr	27
		End of Aerobic	6 hr	28
		End of Settling	8 hr	28
B3	30	End of Feeding	2 hr	29
		End of Anaerobic	4 hr	43
		End of Aerobic	6 hr	27
		End of Settling	8 hr	27

Appendix V

Inhibition Test Results at 50 ppm

Date of Test: 2-11-97 | Solids | AFFF Conc. = 50 ppm



Inhibition test 2-11-97 TSS, TDS & TS data

	A-1	A-2	A-3	B-1	B-2	B-3
AFFF qty.	0ppm	0ppm	0ppm	50ppm	50ppm	50ppm
TSS						
Empty wt.	1.0525	1.0491	1.049	1.0484	1.0479	1.0503
wt.after heat	1.0932	1.0889	1.0892	1.0738	1.0645	1.0685
vol.of sample	15ML	15ml	15ml	15ml	15ml	15ml
TSS mg/l	2713.3	2653.3	2680	1693.3	1106	1213
TDS						
Empty wt.	0.9586	0.9576	0.9605		0.9546	0.9566
wt.after heat	0.978	0.9756	0.9795		0.9731	0.976
vol.of sample	15ml	15ml	15ml		15ml	15ml
TDS mg/l	1293.3	1200	1266.6		1233.3	1293.33
TS						
Empty wt.	0.9563	0.9584	0.9597	0.96	0.9564	0.9566
wt.after heat	1.0159	1.0175	1.0189	1.0052	0.9933	0.9959
vol.of sample	15ml	15ml	15ml	15ml	15ml	15ml
TS mg/l	3973.3	3940	3946.6	3013.3	2460	2620
Σ(TSS+ TDS)	4006.6	3853.3	3946.6		2339.3	2506

Date of Test: 2-11-97

Solids

AFFF Conc. = 50 ppm

TVS **	2236	2186	2208	1395	911.3	999.51

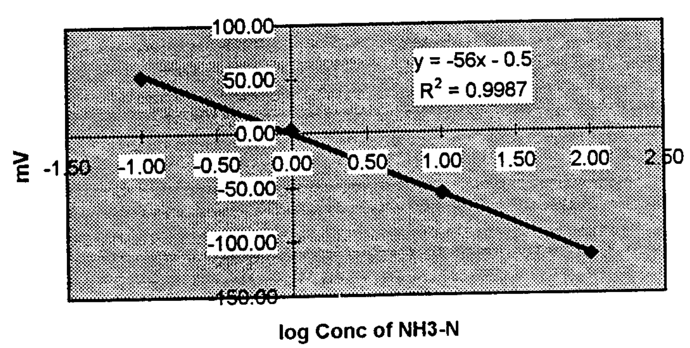
**--TVS were not measured, however since the TVS:TSS ratio is seen to be very stable through-out this phase (82.4%), this ratio is assumed for calculation of the TVS numbers. These TVS numbers will be used in the calculation of the specific oxygen uptake rates for this test.

Reactor	AFFF (ppm)	Stage	Time	mV	NH3-N (mg/L)	log Conc
		Feedstock		-83.00	**29.73**	1.47
		RR Decant		0.90	**0.94**	-0.03
A1	0	End of Feeding	2 hr	-29.00	**3.23**	0.51
		End of Anaerobic	4 hr	-37.00	**4.49**	0.65
		End of Aerobic	6 hr	43.00	**0.17**	-0.78
		End of Settling	8 hr	40.00	**0.19**	-0.72
A2	0	End of Feeding	2 hr	-25.00	**2.74**	0.44
		End of Anaerobic	4 hr	-35.00	**4.13**	0.62
		End of Aerobic	6 hr	-37.00	**4.49**	0.65
		End of Settling	8 hr	40.00	**0.19**	-0.72
A3	0	End of Feeding	2 hr	-33.00	**3.81**	0.58
		End of Anaerobic	4 hr	-38.00	**4.67**	0.67
		End of Aerobic	6 hr	55.00	**0.10**	-1.00
		End of Settling	8 hr	45.00	**0.15**	-0.83
B1	50	End of Feeding	2 hr	-57.00	**9.68**	0.99
		End of Anaerobic	4 hr	-58.00	**10.08**	1.00
		End of Aerobic	6 hr	59.00	**0.08**	-1.08
		End of Settling	8 hr	37.00	**0.20**	-0.69
B2	50	End of Feeding	2 hr	-62.00	**11.88**	1.07
		End of Anaerobic	4 hr	-67.00	**14.59**	1.16
		End of Aerobic	6 hr	5.00	**0.76**	-0.12
		End of Settling	8 hr	9.00	**0.64**	-0.19
B3	50	End of Feeding	2 hr	-61.00	**11.40**	1.06
		End of Anaerobic	4 hr	-65.00	**13.44**	1.13
		End of Aerobic	6 hr	51.00	**0.11**	-0.94
		End of Settling	8 hr	56.00	**0.09**	-1.03

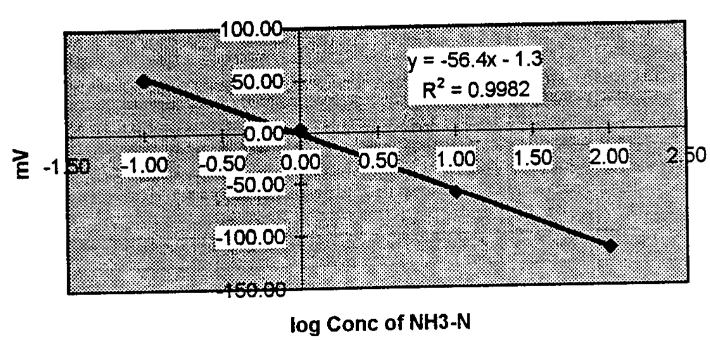
Reactor	AFFF (ppm)	Stage	Time	pH	TKN (mg/L)	Alkalinity HCO3,ml/l
		Feedstock		7.02	**312.5**	363.50
		RR Decant		7.43	**2.1**	101.50
A1	0	End of Feeding	2 hr	7.64	**4.1**	130.50
		End of Anaerobic	4 hr	7.84	**5.8**	200.50
		End of Aerobic	6 hr	7.82	**4.9**	104.00
		End of Settling	8 hr	7.77	**0.5**	134.00
A2	0	End of Feeding	2 hr	7.04	**5.3**	131.00
		End of Anaerobic	4 hr	7.77	**10.3**	148.00
		End of Aerobic	6 hr	7.64	**16.9**	114.00
		End of Settling	8 hr	7.77	**8.4**	131.50
A3	0	End of Feeding	2 hr	7.62	**6.6**	124.50
		End of Anaerobic	4 hr	7.82	**8.7**	149.00
		End of Aerobic	6 hr	7.39	**20.5**	122.00
		End of Settling	8 hr	7.78	**10.1**	122.00
B1	50	End of Feeding	2 hr	7.70	**37.0**	147.00
		End of Anaerobic	4 hr	7.70	**32.7**	162.00
		End of Aerobic	6 hr	7.45	**14.9**	78.00
		End of Settling	8 hr	7.43	**13.2**	78.00
B2	50	End of Feeding	2 hr	7.86	**32.7**	178.00
		End of Anaerobic	4 hr	7.90	**51.4**	194.50
		End of Aerobic	6 hr	7.41	**15.3**	82.00
		End of Settling	8 hr	7.39	**12.2**	84.50
B3	50	End of Feeding	2 hr	7.84	**32.4**	159.00
		End of Anaerobic	4 hr	7.84	**47.3**	186.00
		End of Aerobic	6 hr	7.36	**14.9**	71.50
		End of Settling	8 hr	7.40	**12.4**	75.50

			After A3 4 hr			After A3 6hr		
NH3-N	log Conc	mV	NH3-N	log Conc	mV	NH3-N	log Conc	mV
0.10	-1.00	53.00	0.10	-1.00	53.00	0.10	-1.00	52.00
1.00	0.00	3.00	1.00	0.00	3.00	1.00	0.00	3.00
10.00	1.00	-56.00	10.00	1.00	-60.00	10.00	1.00	-60.00
100.00	2.00	-114.00	100.00	2.00	-114.00	100.00	2.00	-114.00

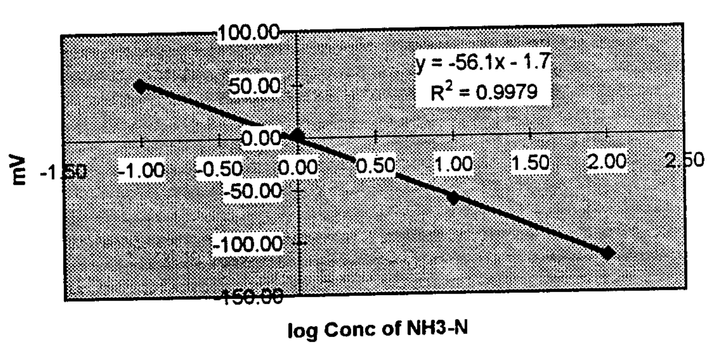
Original NH3-N Standards



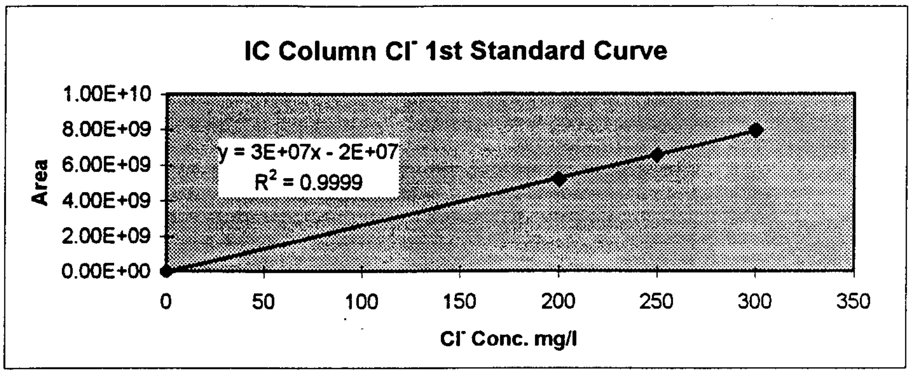
NH3-N Standards for samples after A3 4hr



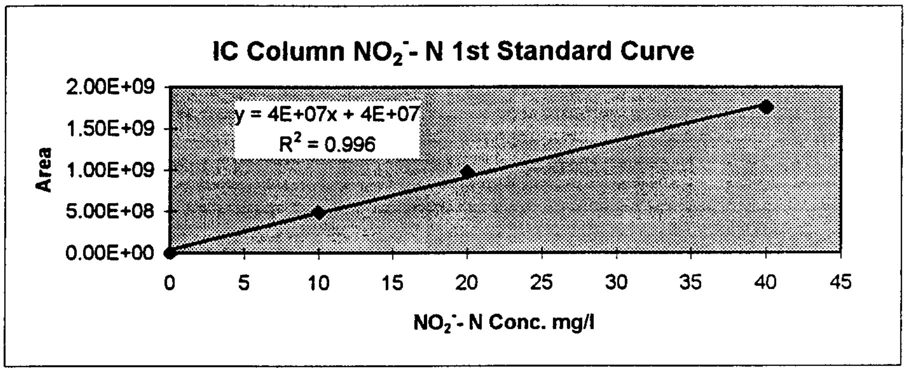
NH3-N Standards for samples after A3 6hr



26277641.58 m
-17518957.8 l



43808563.36 m
41801007.2 l



55779071.25 m
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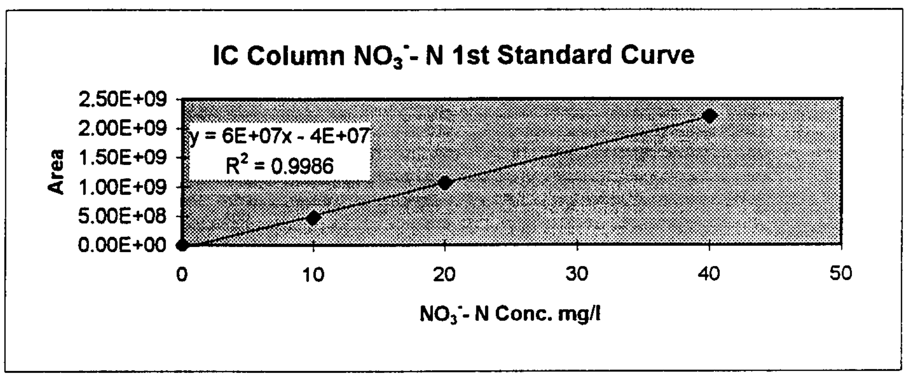
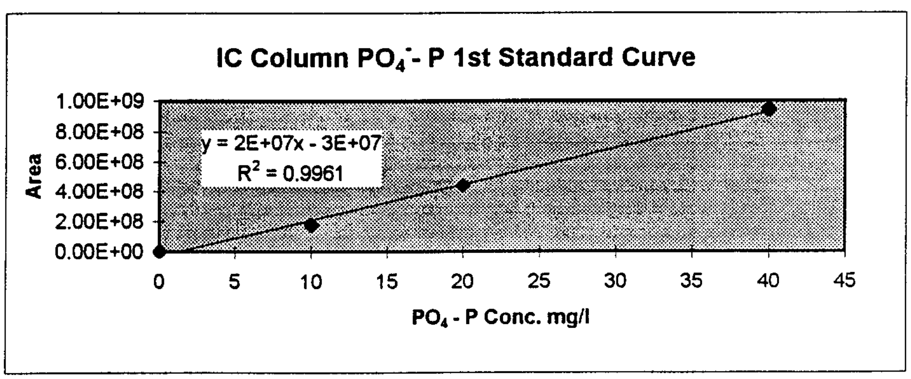
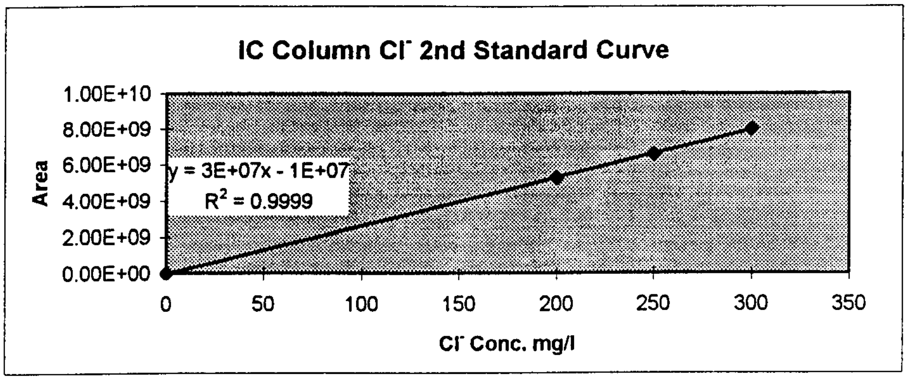


24015166.15 m
-27894994.6 l





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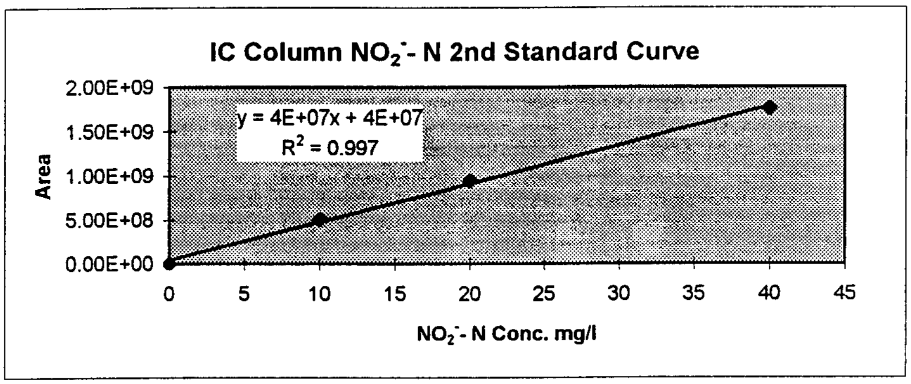
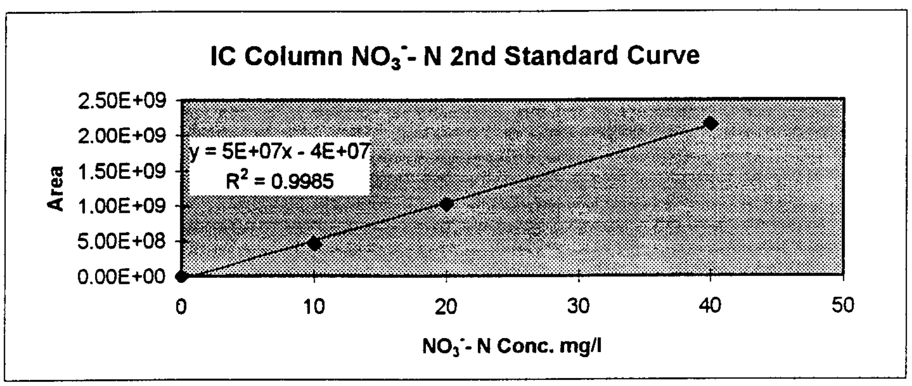


m	43578913.56
l	43179892.4



m	54547340.6
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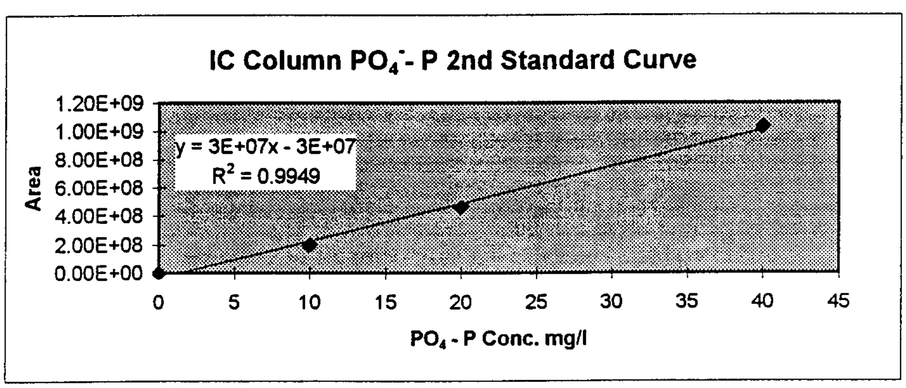
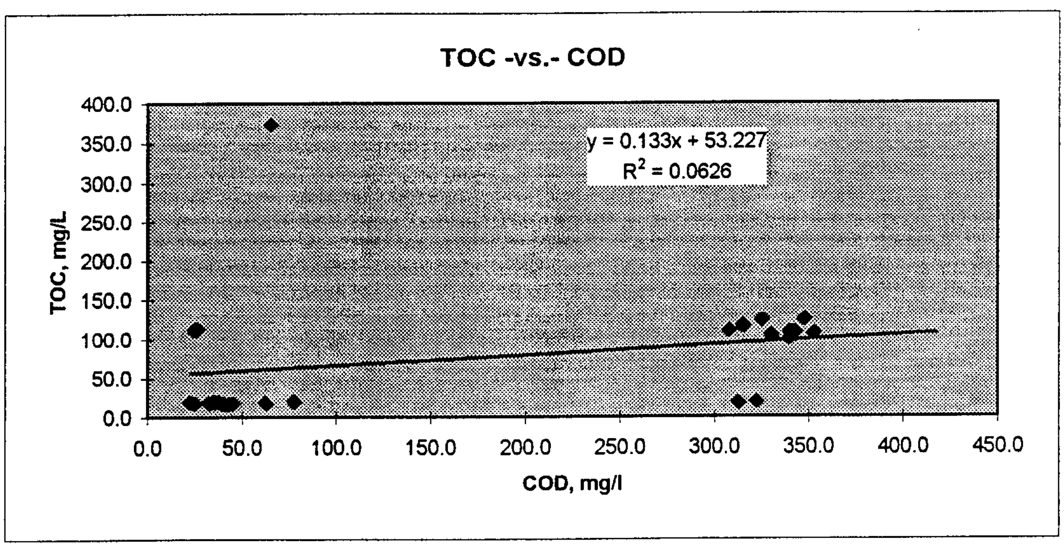


m	26204823.37
l	-34171583

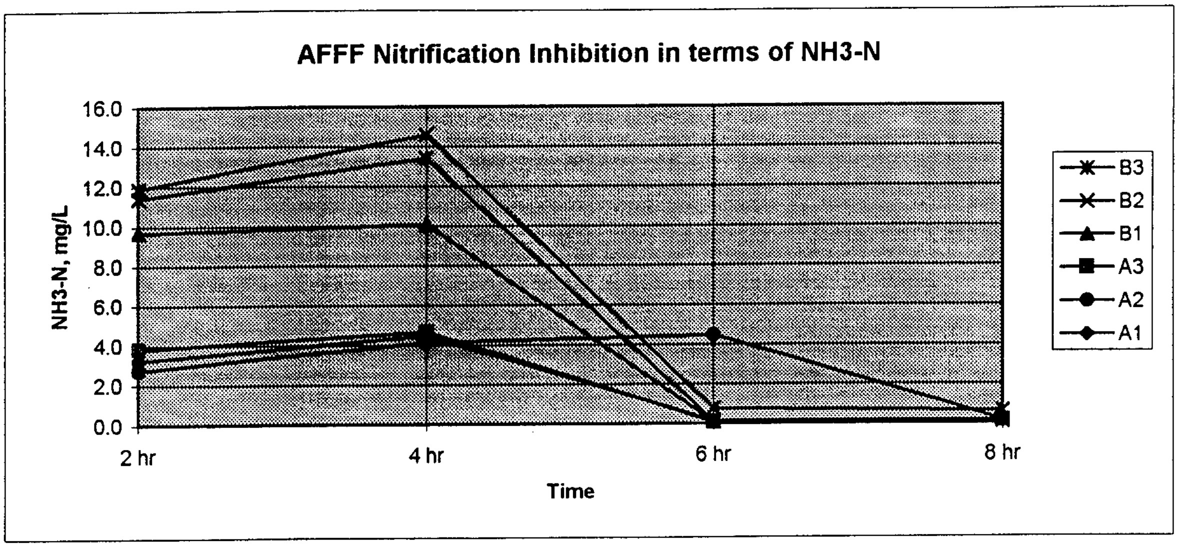
Reactor	AFFF (ppm)	Stage	Time	Cl- Area	Cl- (mg/L)	NO_2^--N Area	NO_2^--N (mg/L)	NO_3^--N Area	NO_3^--N (mg/L)	PO_4^--P Area	PO_4^--P (mg/L)
		Feedstock		6902916074	263.4	0		2819369	0.7	490997565	26.0
		RR Decant		7340715455	280.0	0		5856618969	105.7	613284211	32.2
A1	0	End of Feeding	2 hr	6900651189	263.3	116099477	1.7	4580249295	82.8	699470794	30.3
		End of Anaerobic	4 hr	6788329122	259.0			3941287534	71.3	666361173	28.9
		End of Aerobic	6 hr	6780166083	258.7			4441900197	80.3	618706583	26.9
		End of Settling	8 hr	7401907491	282.3			5156063533	93.1	694107875	30.1
A2	0	End of Feeding	2 hr	6879858891	260.1	94852761	1.2	4543897972	84.0	773287324	30.8
		End of Anaerobic	4 hr	7054603352	266.7			4140181354	76.6	758969936	30.3
		End of Aerobic	6 hr	6974568488	263.7			4511654345	83.4	690776370	27.7
		End of Settling	8 hr	7123823221	269.3			4630086599	85.6	708409935	28.3
A3	0	End of Feeding	2 hr	6991517861	264.3	71566511	0.7	4573118603	84.6	726775811	29.0
		End of Anaerobic	4 hr	6756991471	255.5			3951797329	73.2	684281107	27.4
		End of Aerobic	6 hr	6895252864	260.7			4465534453	82.6	639426596	25.7
		End of Settling	8 hr	7136356050	269.8			4654831041	86.1	670168766	26.9
B1	50	End of Feeding	2 hr	7195464338	274.5	158126286	2.7	4585372854	82.9	704131641	30.5
		End of Anaerobic	4 hr	6942734235	264.9	49379782	0.2	4044064291	73.2	664994657	28.9
		End of Aerobic	6 hr	7732978141	294.9			5615042831	101.3	690036541	29.9
		End of Settling	8 hr			[redacted]		5335617567	96.3	710977150	30.8
B2	50	End of Feeding	2 hr	6984104315	264.0	192225661	3.4	4086034572	75.6	783433942	31.2
		End of Anaerobic	4 hr	6770157368	256.0	93579589	1.2	3796814406	70.3	727754360	29.1
		End of Aerobic	6 hr	6983643100	264.0	117909029	1.7	4839726580	89.4	750147256	29.9
		End of Settling	8 hr	7024018843	265.6	123075846	1.8	4907342461	90.7	751135129	30.0
B3	50	End of Feeding	2 hr	6917642063	261.5	190187341	3.4	4198101459	77.7	720842915	28.8
		End of Anaerobic	4 hr	6738315130	254.6	74919241	0.7	3782792090	70.1	679528693	27.2
		End of Aerobic	6 hr	6936233600	262.2			5110359510	94.4	689771094	27.6
		End of Settling	8 hr	7044032300	266.3			5168806769	95.5	694199078	27.8
		Standards used for A1 & B1 samples.									
		STD 1		63968	0	0	0	0	0	0	0
		STD 2		5190043433	200	495391248	10	476086704	10	181634573	10
		STD 3		6542325734	250	978317378	20	1066733499	20	442551480	20
		STD 4		7905722220	300	1760094838	40	2209355728	40	945295599	40
		Stand 2		5210150549	198.9	514276563	10.8	480410251	9.3	177069070	8.5
		Standards used for A2, A3, B2, & B3 samples.									
		STD 1b		0	0	0	0	0	0	0	0
		STD 2b		5278052742	200	511830017	10	465683608	10	200270737	10
		STD 3b		6570991874	250	951826465	20	1033493797	20	462990589	20
		STD 4b		7977236821	300	1759587037	40	2161680693	40	1034389978	40
		Stand 4		7945526585	300.3	1788115950	40.0	2197852912	41.0	976832506	38.6
		Stand 3		6459804823	244.3	931333776	20.4	1047262452	19.9	399135809	16.5
		B1_6HR		7154498980	270.5			5127307749	94.7	679017920	27.2
		B1_8HR		7109272120	268.8			5036612488	93.1	679267488	27.2
		B1_2HR		6938016769	262.3	150486559	2.6	4323680326	80.0	691331468	27.7

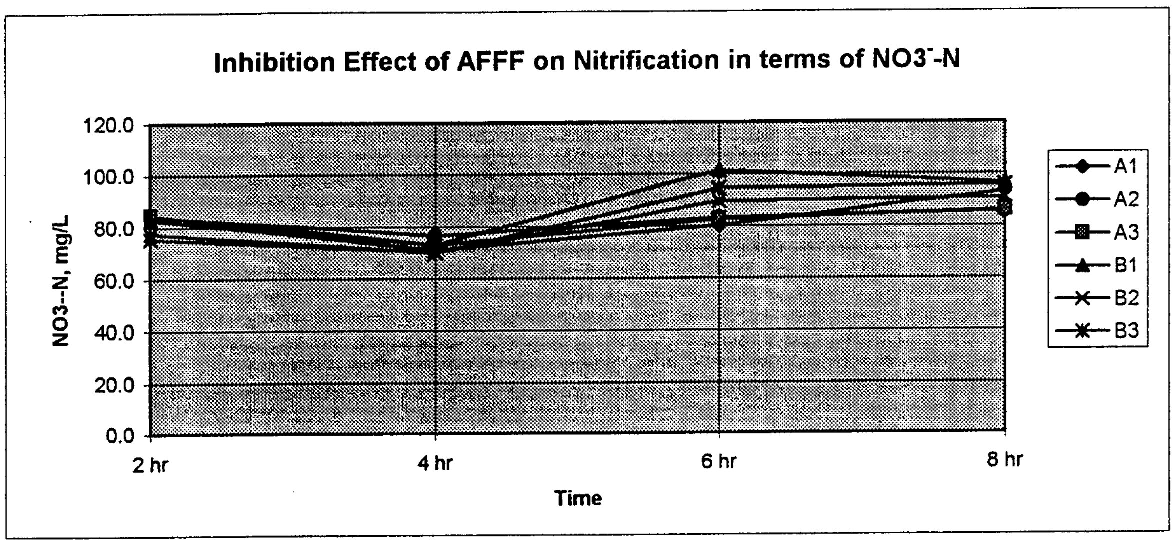
Date of Test: 2-11-97 Concentrations Table AFFF Conc. = 50 ppm

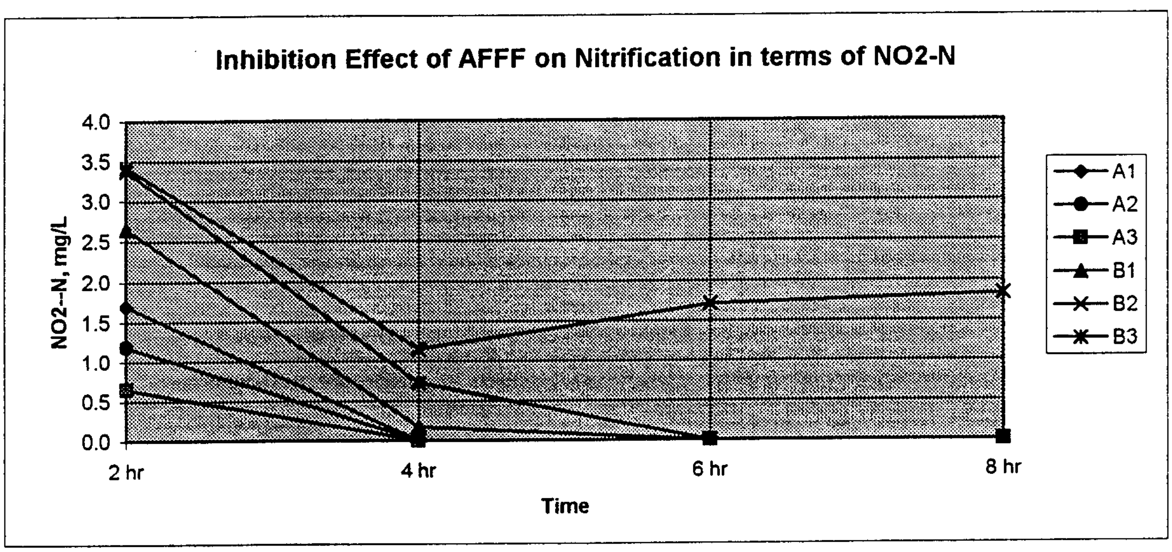
Reactor	AFFF (ppm)	Stage	Time	pH	TKN	NH3-N	Org. N	NO2--N	NO3--N	Total N	Cl-	PO4-P
					Concentration, mg/L							
		Feedstock		7.02	312.5	29.7	282.7	0.0	0.7	313.2	263.4	26.0
		RR Decant		7.43	2.1	0.9	1.1	0.0	105.7	107.7	280.0	32.2
A1	0	End of Feeding	2 hr	7.64	4.1	3.2	0.9	1.7	82.8	88.6	263.3	30.3
		End of Anaerobic	4 hr	7.84	5.8	4.5	1.3	0.0	71.3	77.1	259.0	28.9
		End of Aerobic	6 hr	7.82	4.9	0.2	4.7	0.0	80.3	85.2	258.7	26.9
		End of Settling	8 hr	7.77	0.5	0.2	0.3	0.0	93.1	93.7	282.3	30.1
A2	0	End of Feeding	2 hr	7.04	5.3	2.7	2.6	1.2	84.0	90.5	260.1	30.8
		End of Anaerobic	4 hr	7.77	10.3	4.1	6.2	0.0	76.6	86.9	266.7	30.3
		End of Aerobic	6 hr	7.64	16.9	4.5	12.4	0.0	83.4	100.3	263.7	27.7
		End of Settling	8 hr	7.77	8.4	0.2	8.2	0.0	85.6	94.0	269.3	28.3
A3	0	End of Feeding	2 hr	7.62	6.6	3.8	2.7	0.7	84.6	91.8	264.3	29.0
		End of Anaerobic	4 hr	7.82	8.7	4.7	4.1	0.0	73.2	81.9	255.5	27.4
		End of Aerobic	6 hr	7.39	20.5	0.1	20.4	0.0	82.6	103.1	260.7	25.7
		End of Settling	8 hr	7.78	10.1	0.1	10.0	0.0	86.1	96.2	269.8	26.9
B1	50	End of Feeding	2 hr	7.70	37.0	9.7	27.3	2.7	82.9	122.5	274.5	30.5
		End of Anaerobic	4 hr	7.70	32.7	10.1	22.6	0.2	73.2	106.0	264.9	28.9
		End of Aerobic	6 hr	7.45	14.9	0.1	14.8	0.0	101.3	116.2	294.9	29.9
		End of Settling	8 hr	7.43	13.2	0.2	13.0	0.0	96.3	109.6	0.0	30.8
B2	50	End of Feeding	2 hr	7.86	32.7	11.9	20.8	3.4	75.6	111.7	264.0	31.2
		End of Anaerobic	4 hr	7.90	51.4	14.6	36.8	1.2	70.3	122.9	256.0	29.1
		End of Aerobic	6 hr	7.41	15.3	0.8	14.5	1.7	89.4	106.4	264.0	29.9
		End of Settling	8 hr	7.39	12.2	0.6	11.5	1.8	90.7	104.7	265.6	30.0
B3	50	End of Feeding	2 hr	7.84	32.4	11.4	21.0	3.4	77.7	113.4	261.5	28.8
		End of Anaerobic	4 hr	7.84	47.3	13.4	33.9	0.7	70.1	118.1	254.8	27.2
		End of Aerobic	6 hr	7.36	14.9	0.1	14.8	0.0	94.4	109.3	262.2	27.6
		End of Settling	8 hr	7.40	12.4	0.1	12.3	0.0	95.5	107.9	266.3	27.8

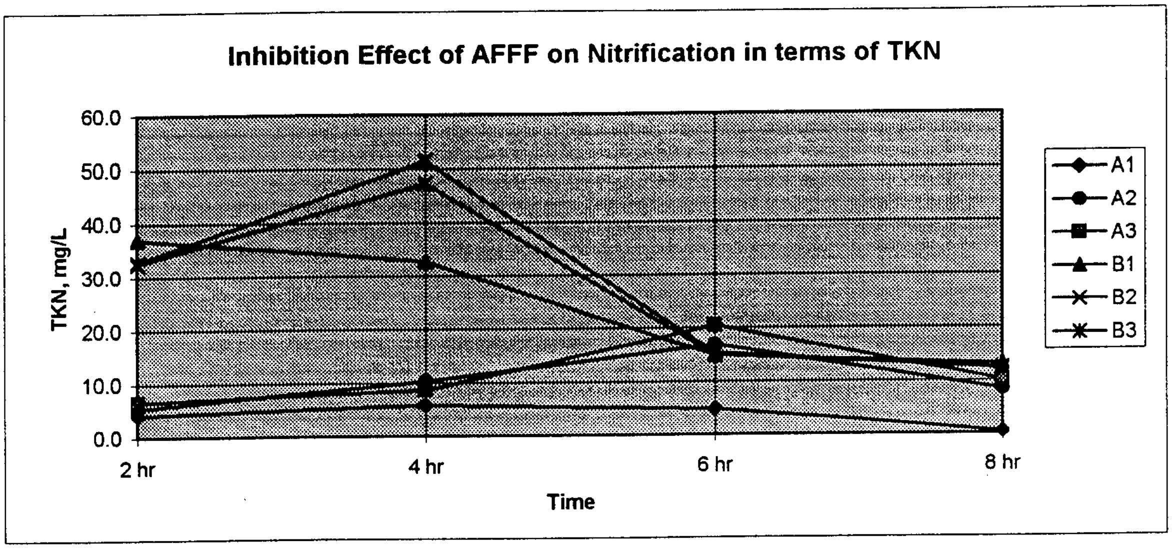


Date of Test: 2-11-97 NH3-N & TKN Charts AFFF Conc. = 50 ppm

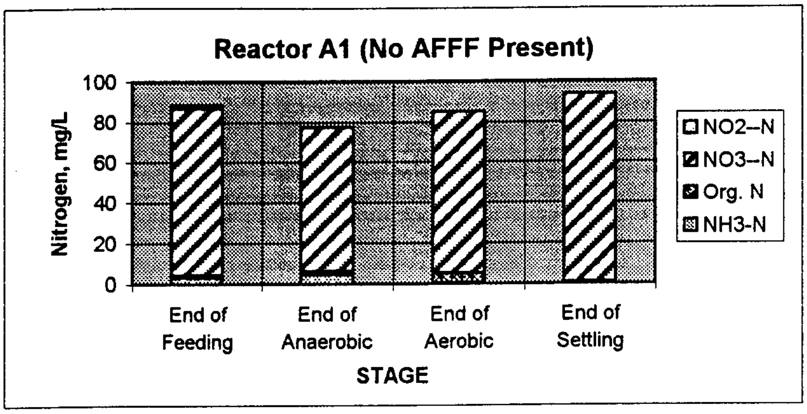


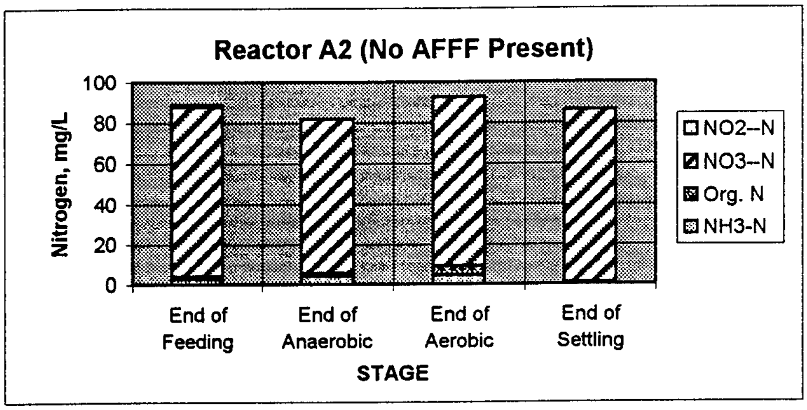


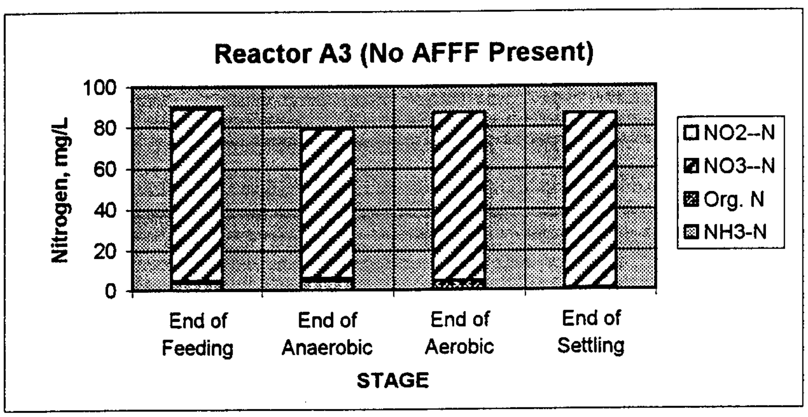



Inhibition Effect of AFFF on Nitrification in terms of TKN
60.0
50.0
40.0
30.0
20.0
10.0
0.0
TKN, mg/L
2 hr
4 hr
6 hr
8 hr
Time
A1
A2
A3
B1
B2
B3

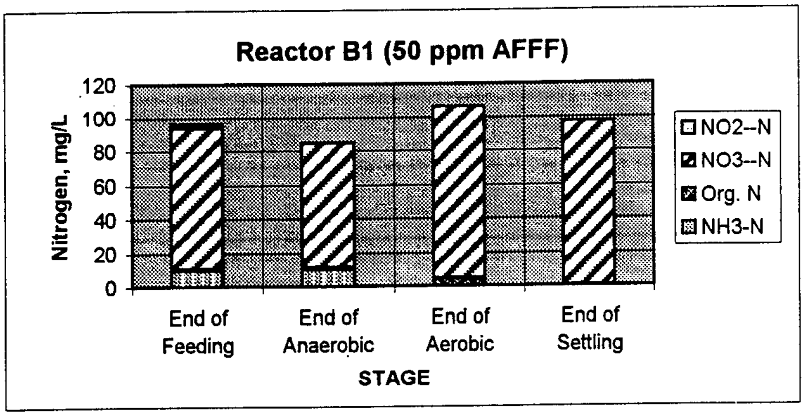
Date of Test: 2-11-97 Inhibition Reactors / Nitrogen Mass Balance AFFF Cons. = 50 ppm

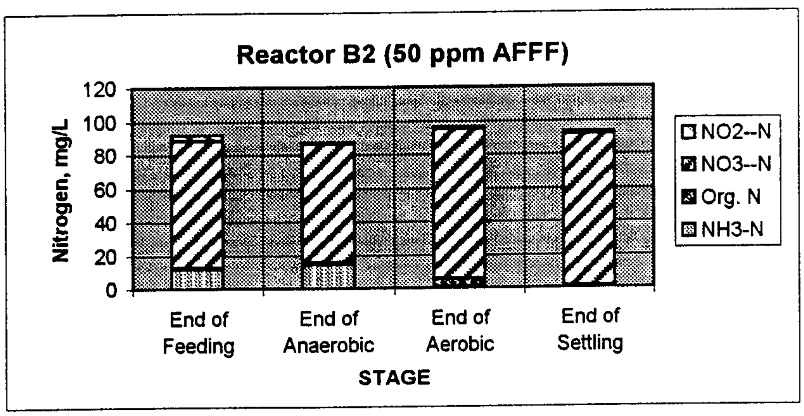


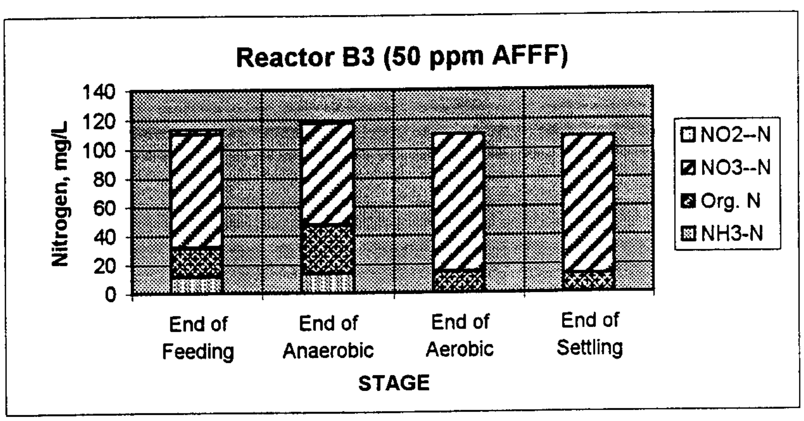




Date of Test: 2-11-97 Inhibition Reactors / Nitrogen Mass Balance AFFF Cons. = 50 ppm

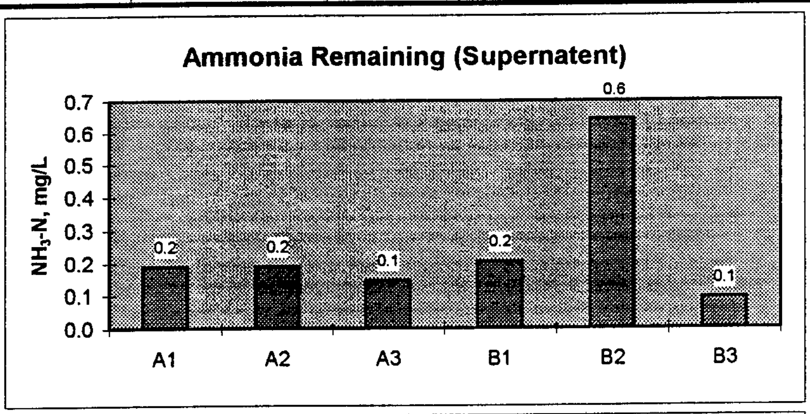


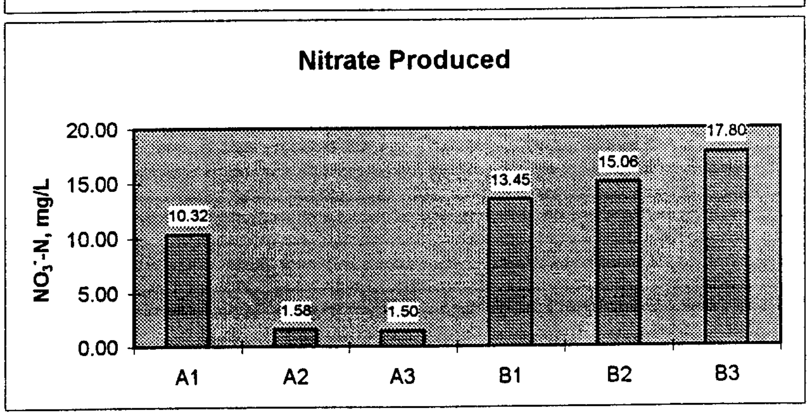




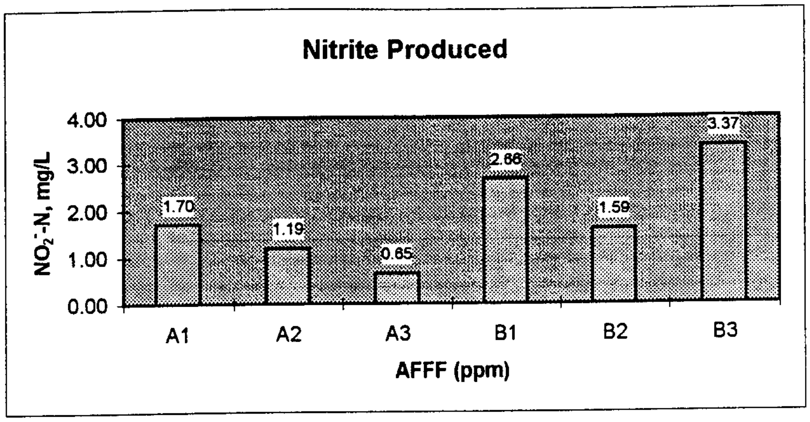
Date of Test: 2-11-97 Inhibition Reactors / NO3- & NO2 Produced AFFF Conc. = 50 ppm

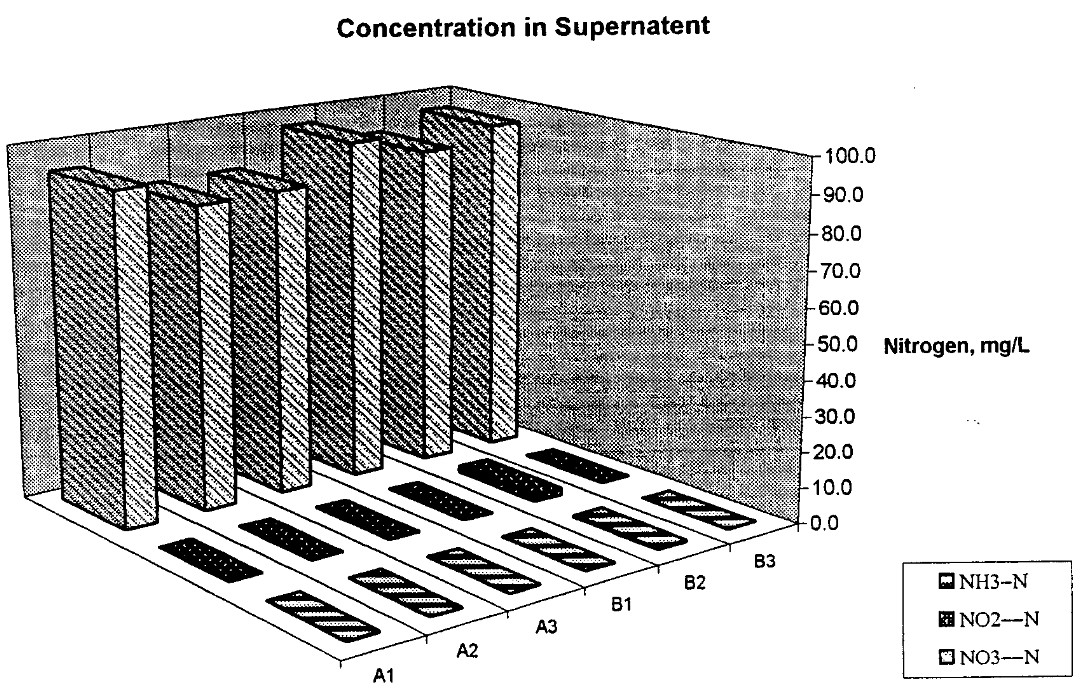
				Nitrogen Concentration, mg/L				
Reactor	**AFFF ppm**	**Stage**	**Time**	**NH3-N**	**NO3--N**	**NO2--N**	$\Delta(NO_3^-\text{-N})$	$\Delta(NO_2\text{-N})$
A1	0	End of Feeding	2 hr	3.2	82.8	1.7		
(Control)		End of Anaerobic	4 hr	4.5	71.3	0.0		
		End of Aerobic	6 hr	0.2	80.3	0.0		
		End of Settling	8 hr	0.2	93.1	0.0	10.32	1.70
A2	0	End of Feeding	2 hr	2.7	84.0	1.2		
(Control)		End of Anaerobic	4 hr	4.1	76.6	0.0		
		End of Aerobic	6 hr	4.5	83.4	0.0		
		End of Settling	8 hr	0.2	85.6	0.0	1.58	1.19
A3	0	End of Feeding	2 hr	3.8	84.6	0.7		
(Control)		End of Anaerobic	4 hr	4.7	73.2	0.0		
		End of Aerobic	6 hr	0.1	82.6	0.0		
		End of Settling	8 hr	0.1	86.1	0.0	1.50	0.65
B1	50	End of Feeding	2 hr	9.7	82.9	2.7		
		End of Anaerobic	4 hr	10.1	73.2	0.2		
		End of Aerobic	6 hr	0.1	101.3	0.0		
		End of Settling	8 hr	0.2	96.3	0.0	13.45	2.66
B2	50	End of Feeding	2 hr	11.9	75.6	3.4		
		End of Anaerobic	4 hr	14.6	70.3	1.2		
		End of Aerobic	6 hr	0.8	89.4	1.7		
		End of Settling	8 hr	0.6	90.7	1.8	15.06	1.59
B3	50	End of Feeding	2 hr	11.4	77.7	3.4		
		End of Anaerobic	4 hr	13.4	70.1	0.7		
		End of Aerobic	6 hr	0.1	94.4	0.0		
		End of Settling	8 hr	0.1	95.5	0.0	17.80	3.37





Date of Test: 2-11-97 | Inhibition Reactors / NO3- & NO2 Produced | AFFF Conc. = 50 ppm





Date of Test: 2-11-97

Concentrations Table

AFFF Conc. = 50 ppm

Reactor	AFFF (ppm)	Stage	Time	Concentration, mg/L BOD	COD	TCOD	TOC	COD:BOD
	-	Feedstock		560	997.5	997.5	373.2	1.8
		RR Decant		-14	78.8	77.5	19.8	-5.6
A1	0	End of Feeding	2 hr	-6	65.0	52.5	18.9	-10.8
		End of Anaerobic	4 hr	-7	35.0	365.0	18.7	-5.0
		End of Aerobic	6 hr	-5	22.5	32.5	20.0	-4.5
		End of Settling	8 hr	-2	25.0	77.5	18.7	-16.7
A2	0	End of Feeding	2 hr	-13	77.5	0.0	18.5	-6.0
		End of Anaerobic	4 hr	-7	45.0	0.0		-6.4
		End of Aerobic	6 hr	-8	32.5	15.0	18.5	-4.1
		End of Settling	8 hr	-3	45.0	0.0	17.2	-18.0
A3	0	End of Feeding	2 hr	-7	62.5	0.0	20.2	-8.9
		End of Anaerobic	4 hr	-6	42.5	0.0	18.0	-7.1
		End of Aerobic	6 hr	-8	37.5	20.0	18.9	-4.7
		End of Settling	8 hr	-2	40.0	0.0	18.3	-20.0
B1	50	End of Feeding	2 hr	25	322.5	432.5	110.6	12.9
		End of Anaerobic	4 hr	20	312.5	385.0	104.9	15.6
		End of Aerobic	6 hr	22	307.5	47.5		14.0
		End of Settling	8 hr	20	330.0	337.5	100.0	16.9
B2	50	End of Feeding	2 hr	40	417.5	0.0	117.1	10.4
		End of Anaerobic	4 hr	8	340.0	0.0	125.0	42.5
		End of Aerobic	6 hr	6	315.0	62.5	107.4	52.5
		End of Settling	8 hr	27	347.5	0.0	109.3	13.1
B3	50	End of Feeding	2 hr	37	352.5	0.0	124.3	9.5
		End of Anaerobic	4 hr	31	340.0	0.0	109.1	11.0
		End of Aerobic	6 hr	28	325.0	87.5	112.7	11.6
		End of Settling	8 hr	28	342.5	0.00	113.0	12.5

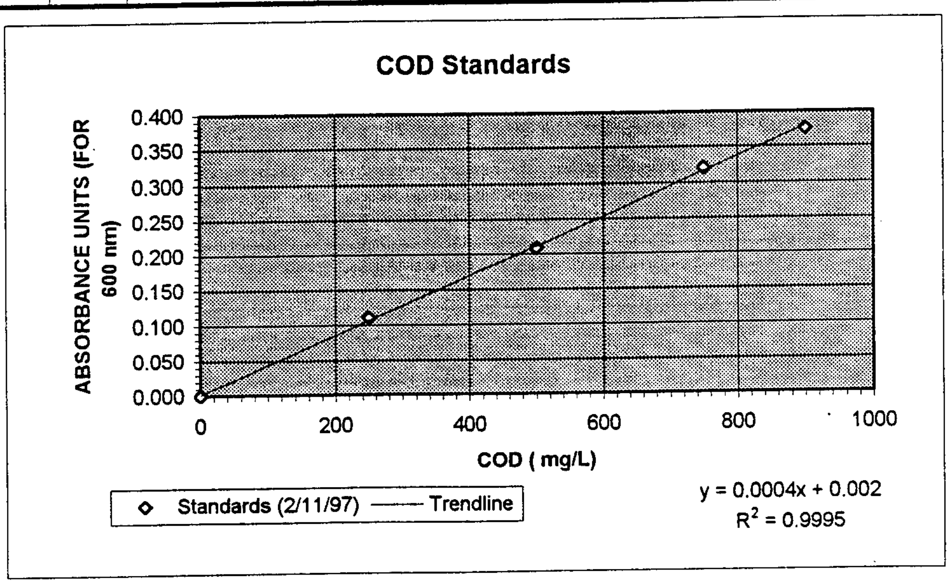
Date of Test: 2-11-97

COD

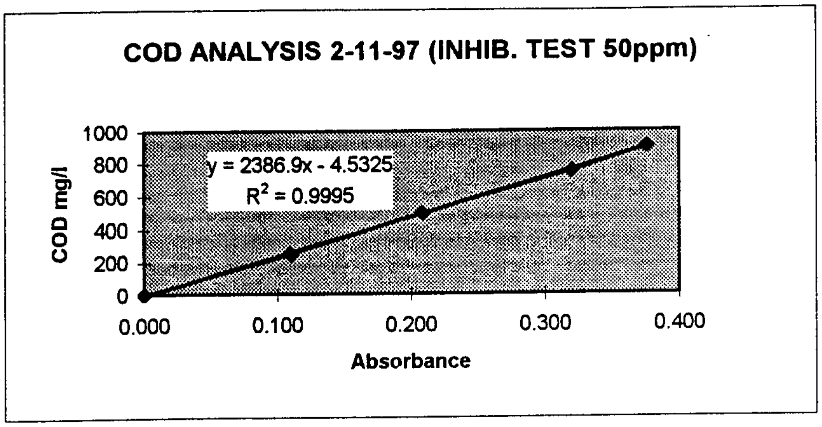
AFFF Conc. = 50 ppm

Reactor	Sample	Time	ABSORB.	COD mg/l	COD % Removal
	Blank		0.000	0	
	std-1(250mg/l)		0.110	250	
	std-2(500mg/l)		0.209	500	
	std-3(750mg/l		0.320	750	
	std-4(900mg/l)		0.376	900	
	Feedstock-1		0.398	945.5	
	Feedstock-2		0.404	959.8	
	Ref.Re. SU-1		0.033	74.2	92.2
	Ref.Re. SU-2		0.034	76.6	91.9
A1 (0)	End of Feeding	2 hr	0.028	62.3	83.0
	End of Anaerobic	4 hr	0.016	33.7	90.8
	End of Aerobic	6 hr	0.011	21.7	94.1
	End of Settling	8 hr	0.012	24.1	**93.4**
A2 (0)	End of Feeding	2 hr	0.033	74.2	79.8
	End of Anaerobic	4 hr	0.020	43.2	88.2
	End of Aerobic	6 hr	0.015	31.3	91.5
	End of Settling	8 hr	0.020	43.2	**88.2**
A3 (0)	End of Feeding	2 hr	0.027	59.9	83.7
	End of Anaerobic	4 hr	0.019	40.8	88.9
	End of Aerobic	6 hr	0.017	36.0	90.2
	End of Settling	8 hr	0.018	38.4	**89.5**
B1 (50)	End of Feeding	2 hr	0.131	308.2	68.4
	End of Anaerobic	4 hr	0.127	298.6	69.4
	End of Aerobic	6 hr	0.125	293.8	69.9
	End of Settling	8 hr	0.134	315.3	**67.7**
B2 (50)	End of Feeding	2 hr	0.169	398.9	59.1
	End of Anaerobic	4 hr	0.138	324.9	66.7
	End of Aerobic	6 hr	0.128	301.0	69.2
	End of Settling	8 hr	0.141	332.0	**66.0**
B3 (50)	End of Feeding	2 hr	0.143	336.8	65.5
	End of Anaerobic	4 hr	0.138	324.9	66.7
	End of Aerobic	6 hr	0.132	310.5	68.2
	End of Settling	8 hr	0.139	327.2	**66.5**
Total COD's					
A1 (0) (T)	End of Feeding	2 hr	0.023	50.4	94.7
	End of Anaerobic	4 hr	0.148	348.7	63.3
	End of Settling	8 hr	0.033	74.2	92.2
B1 (50) (T)	End of Feeding	2 hr	0.175	413.2	56.5
	End of Anaerobic	4 hr	0.156	367.8	61.3
	End of Settling	8 hr	0.137	322.5	66.1

Reactor	AFFF (ppm)	Stage	Time	COD ABS	COD (mg/L)	Total COD ABS	Total COD (mg/L)
		Feedstock		0.401	**997.5**		**997.5**
		RR Decant		0.034	**78.8**		**77.5**
A1	0	End of Feeding	2 hr	0.028	**65.0**	0.023	**52.5**
		End of Anaerobic	4 hr	0.016	**35.0**	0.148	**365.0**
		End of Aerobic	6 hr	0.011	**22.5**	0.015	**32.5**
		End of Settling	8 hr	0.012	**25.0**	0.033	**77.5**
A2	0	End of Feeding	2 hr	0.033	**77.5**		
		End of Anaerobic	4 hr	0.020	**45.0**		
		End of Aerobic	6 hr	0.015	**32.5**	0.008	**15.0**
		End of Settling	8 hr	0.020	**45.0**		
A3	0	End of Feeding	2 hr	0.027	**62.5**		
		End of Anaerobic	4 hr	0.019	**42.5**		
		End of Aerobic	6 hr	0.017	**37.5**	0.010	**20.0**
		End of Settling	8 hr	0.018	**40.0**		
B1	50	End of Feeding	2 hr	0.131	**322.5**	0.175	**432.5**
		End of Anaerobic	4 hr	0.127	**312.5**	0.156	**385.0**
		End of Aerobic	6 hr	0.125	**307.5**	0.021	**47.5**
		End of Settling	8 hr	0.134	**330.0**	0.137	**337.5**
B2	50	End of Feeding	2 hr	0.169	**417.5**		
		End of Anaerobic	4 hr	0.138	**340.0**		
		End of Aerobic	6 hr	0.128	**315.0**	0.027	**62.5**
		End of Settling	8 hr	0.141	**347.5**		
B3	50	End of Feeding	2 hr	0.143	**352.5**		
		End of Anaerobic	4 hr	0.138	**340.0**		
		End of Aerobic	6 hr	0.132	**325.0**	0.037	**87.5**
		End of Settling	8 hr	0.139	**342.5**		
		STD 1		0.000	0		
		STD 2		0.110	250		
		STD 3		0.209	500		
		STD 4		0.320	750		
		STD 5		0.376	900		



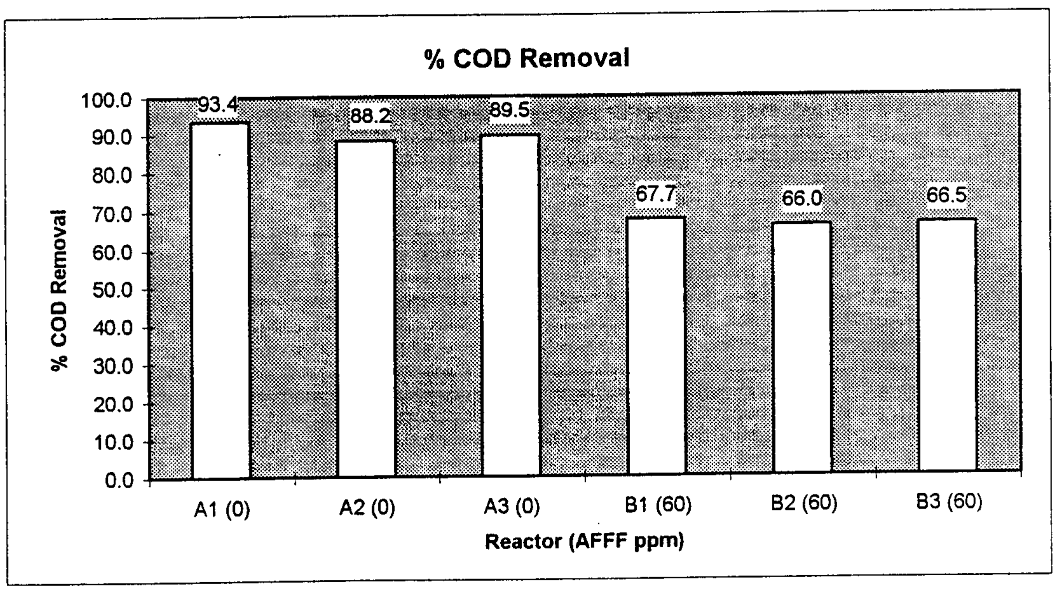
Date of Test: 2-11-97 COD AFFF Conc. = 50 ppm



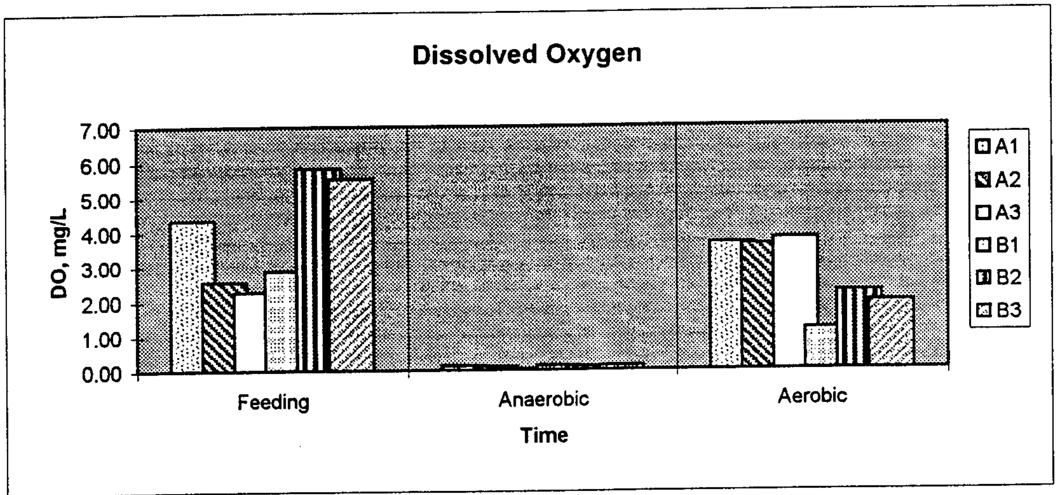
Summary for COD and Total COD analysis in mg/l									
		COD mg/l						TCOD mg/l	
STAGE	TIME	A1 (0)	A2 (0)	A3 (0)	B1 (50)	B2 (50)	B3 (50)	A1 (0)	B1 (50)
End of fill	2hr	62.3	74.2	59.9	308.2	398.9	336.8	50.4	413.2
End of anaerobic	4hr	33.7	43.2	40.8	298.6	324.9	324.9	~~	367.8
End of aerobic	6hr	21.7	31.3	36.0	293.8	301.0	310.5	~~	~~
Supernatent	8hr	24.1	43.2	38.4	315.3	332.0	327.2	74.2	322.5

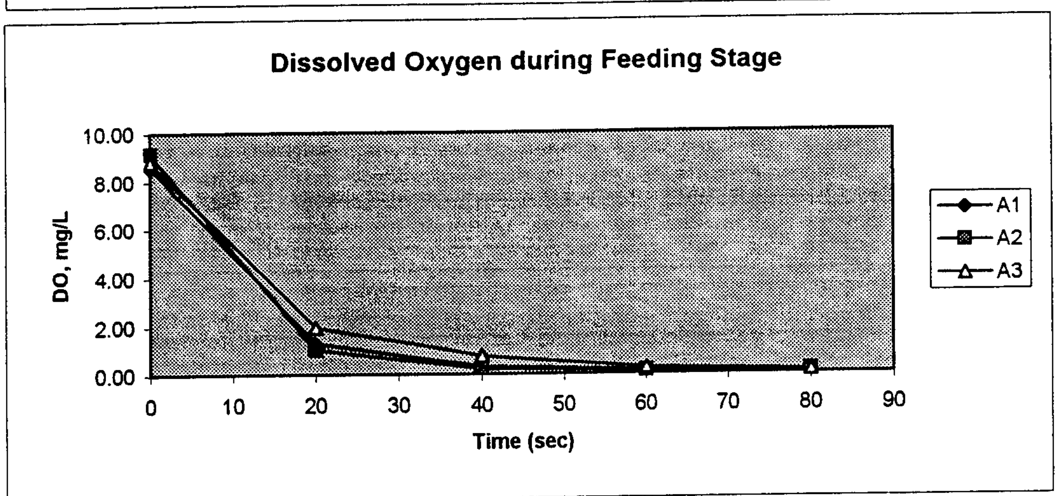
~~ -- data not known

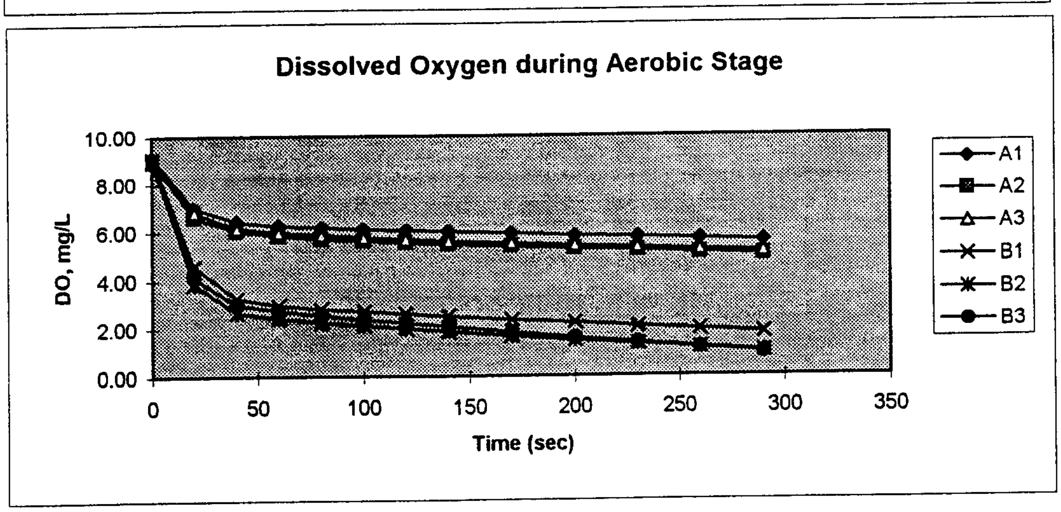
Reactor (AFFF ppm)	A1 (0)	A2 (0)	A3 (0)	B1 (60)	B2 (60)	B3 (60)
% COD Removal	93.4	88.2	89.5	67.7	66.0	66.5



Dissolved Oxygen (mg/L) at various stages							
Time	Stage	A1	A2	A3	B1	B2	B3
1:30 PM	Feeding	4.35	2.56	2.25	2.85	5.84	5.52
2:30 PM	Anaero	0.12	0.11	0.04	0.12	0.11	0.12
4:30 PM	Aerobic	3.65	3.60	3.79	1.18	2.23	1.96

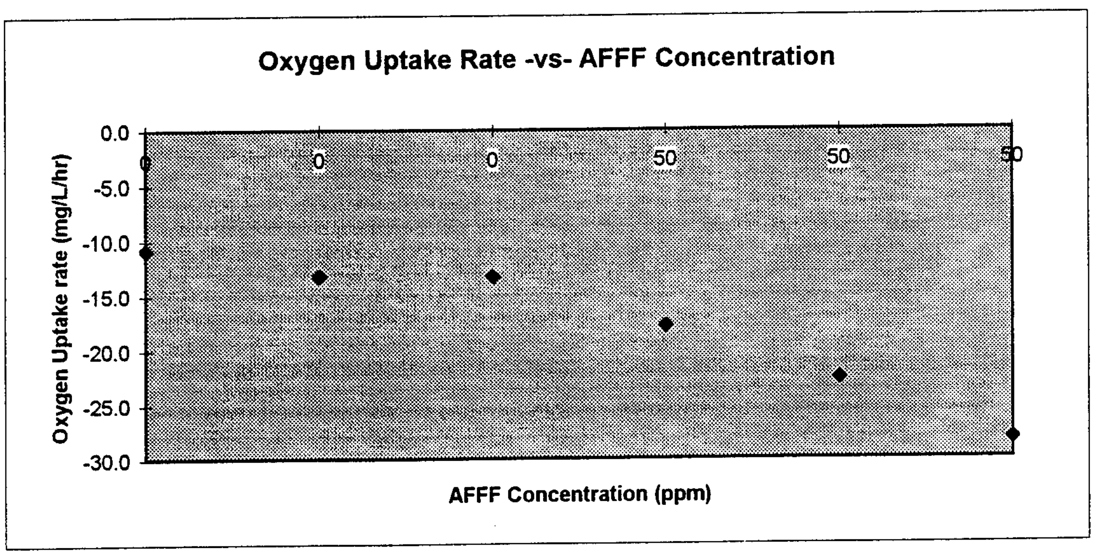






		Dissolved Oxygen in mg/L					
Stage	Time (sec)	A1	A2	A3	B1	B2	B3
Feeding	0	8.60	9.16	8.83			
	20	1.29	1.05	1.98			
	40	0.34	0.23	0.79			
	60	0.15	0.13	0.27			
	80	0.13	0.12	0.13			
Aerobic	0	9.15	9.02	9.08	9.08	8.94	8.90
	20	7.02	6.62	6.84	4.61	3.86	4.13
	40	6.43	6.05	6.15	3.28	2.68	3.02
	60	6.27	5.84	5.97	2.99	2.43	2.75
	80	6.19	5.72	5.86	2.84	2.26	2.56
	100	6.11	5.63	5.77	2.73	2.12	2.39
	120	6.05	5.55	5.69	2.62	1.99	2.23
	140	5.99	5.49	5.62	2.52	1.86	2.07
	170	5.91	5.39	5.52	2.37	1.68	1.84
	200	5.83	5.30	5.43	2.23	1.51	1.62
	230	5.76	5.21	5.34	2.09	1.34	1.40
	260	5.69	5.12	5.24	1.96	1.19	1.20
	290	5.62	5.04	5.16	1.83	1.04	1.00

AFFF		REGRESSION SUMMARY OUTPUT			
(ppm)	Samples	R Square	Intercept	Slope,mg/l/sec	Slope,mg/l/hr
0	A1	0.971	6.447	-0.003	-10.8
0	A2	0.963	6.050	-0.004	-13.2
0	A3	0.975	6.180	-0.004	-13.3
50	B1	0.996	3.233	-0.005	-17.8
50	B2	0.987	2.792	-0.006	-22.6
50	B3	0.994	3.212	-0.008	-28.2



SOUR Calculations

AFFF (ppm)	Samples	Slope,mg/l/hr	TVS**mg/l	Slope,mg/l/hr/VSS
0	A1	-10.7839791	2236	-0.00482
0	A2	-13.2389529	2186	-0.00606
0	A3	-13.271466	2206	-0.00602
50	B1	-17.7882353	1395	-0.01275
50	B2	-22.6140314	911.3	-0.02482
50	B3	-28.2223037	999.51	-0.02824

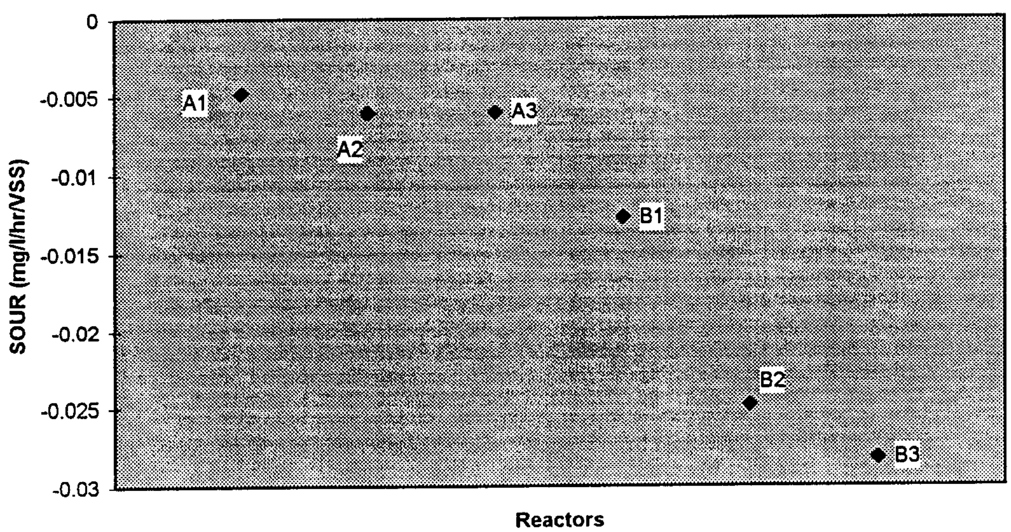


Figure 3-3: Specific Oxygen uptake rates(SOUR's) during the aerobic stage for 50 ppm AFFF (A--Control, B--Inhibition)

Note: The SOUR's are calculated by using VSS, which were calculated by taking the average TSS:VSS ratio for the reference reactor, since they were not actually measured.

Date of Test: 2-11-97

AFFF Conc. = 50 ppm

BOD_5 on Inhibition Reactors

Date, initial: 2/11/97 Date, final: 2/16/97

Bottle No.	108	3	230	115	"Seed"	Blank
Sample Location	Seed Control	Seed Control	Seed Control	Seed Control	***	Blank
% Sample in BOD Bottle	1.0%	1.0%	2.0%	2.0%	1.0%	100.0%
Initial D.O. (mg/L)	7.8	7.8	7.8	7.8	7.8	7.6
Final D.O. (mg/L)	6.3	6.9	4.6	5.5	6.3	7.6
D.O. Depletion	1.5	0.9	3.2	2.3	1.3	0.0
% Seed in BOD Bottle						
Seed Correction						
BOD of Sample (mg/L)	150	90	160	115	129	0

Bottle No.	51	75	L6	187	103	68
Sample Location	Feedstock	Feedstock	Feedstock	RRSU	RRSU	RRSU
% Sample in BOD Bottle	1.0%	1.0%	1.0%	5.0%	5.0%	5.0%
Initial D.O. (mg/L)	7.5	7.5	7.5	7.4	7.5	7.5
Final D.O. (mg/L)	0.2	0.1	0.9	6.6	6.7	6.7
D.O. Depletion	7.3	7.4	6.6	0.8	0.8	0.8
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Seed Correction	1.3	1.3	1.3	1.3	1.3	1.3
BOD of Sample	601	611	531	< 1	< 1	< 1
Average BOD (mg/L)			531			

	Replicates of Reactor B1					
Bottle No.	171	109	14	25A		
Sample Location	B1 2hr	B1 4hr	B1 6hr	B1 8hr		
% Sample in BOD Bottle	1.0%	1.0%	1.0%	1.0%		
Initial D.O. (mg/L)	7.5	7.4	7.5	7.5		
Final D.O. (mg/L)	6.3	6.6	6.8	4.4		
D.O. Depletion	1.2	0.8	0.7	3.1		
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%		
Seed Correction	1.3	1.3	1.3	1.3		
BOD of Sample	< 1	< 1	< 1	181		

	Time 2 hr					
Bottle No.	4	53	63	358	10	64
Sample Location	A1	A2	A3	B1	B2	B3
% Sample in BOD Bottle	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
Initial D.O. (mg/L)	7.6	7.5	7.5	7.5	7.5	7.5
Final D.O. (mg/L)	6.7	7.3	6.7	3.5	2.0	2.3
D.O. Depletion	0.9	0.2	0.8	4.0	5.5	5.2
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Seed Correction	1.3	1.3	1.3	1.3	1.3	1.3
BOD of Sample	< 1	< 1	< 1	27	42	39
Average BOD (mg/L)					36	

Date of Test: 2-11-97

AFFF Conc. = 50 ppm

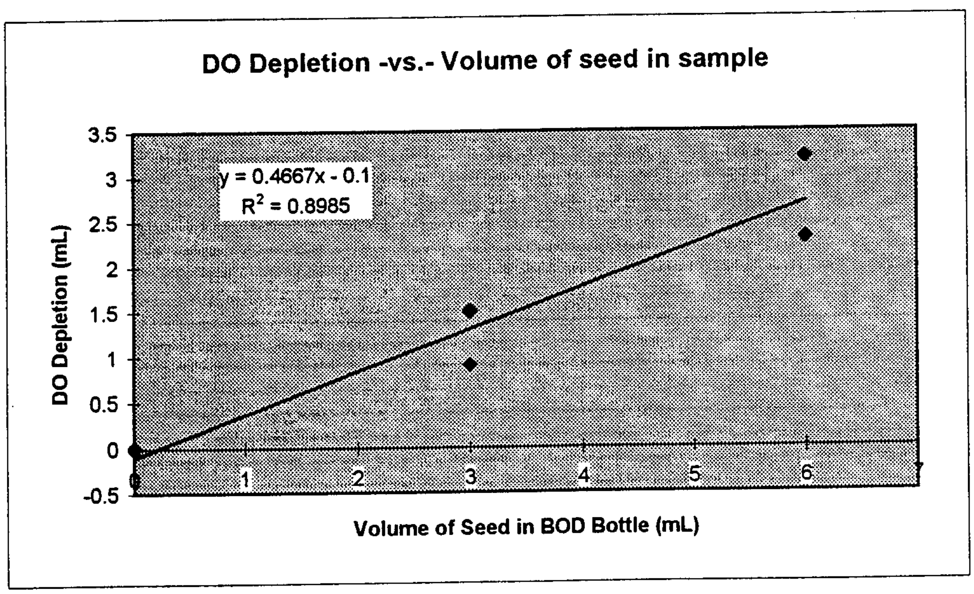
	Time 4 hr					
Bottle No.	444	555	666	777	888	999
Sample Location	A1	A2	A3	B1	B2	B3
% Sample in BOD Bottle	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
Initial D.O. (mg/L)	7.5	7.6	7.6	7.6	7.6	7.5
Final D.O. (mg/L)	6.7	6.8	6.7	4.1	5.3	2.9
D.O. Depletion	0.8	0.8	0.9	3.5	2.3	4.6
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Seed Correction	1.3	1.3	1.3	1.3	1.3	1.3
BOD of Sample	< 1	< 1	< 1	22	10	33
Average BOD (mg/L)					22	

	Time 6 hr					
Bottle No.	56	28	114	23	179	107
Sample Location	A1	A2	A3	B1	B2	B3
% Sample in BOD Bottle	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
Initial D.O. (mg/L)	7.6	7.6	7.5	7.5	7.5	7.5
Final D.O. (mg/L)	6.6	6.9	6.8	3.8	5.4	3.2
D.O. Depletion	1.0	0.7	0.7	3.7	2.1	4.3
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Seed Correction	1.3	1.3	1.3	1.3	1.3	1.3
BOD of Sample	< 1	< 1	< 1	24	8	30
Average BOD (mg/L)					21	

	Time 8 hr					
Bottle No.	111	41	192	48	66	70
Sample Location	A1	A2	A3	B1	B2	B3
% Sample in BOD Bottle	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
Initial D.O. (mg/L)	7.4	7.4	7.4	7.4	7.4	7.4
Final D.O. (mg/L)	6.2	6.4	6.3	2.0	0.6	0.4
D.O. Depletion	1.2	1.0	1.1	5.4	6.8	7.0
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Seed Correction	1.3	1.3	1.3	1.3	1.3	1.3
BOD of Sample	< 1	< 1	< 1	21	28	29
Average BOD (mg/L)					26	

Reactor	AFFF (ppm)	Stage	Time	BOD5
		Feedstock		#REF!
		RR Decant		#REF!
A1	0	End of Feeding	2 hr	< 1
		End of Anaerobic	4 hr	-7
		End of Aerobic	6 hr	-5
		End of Settling	8 hr	-2
A2	0	End of Feeding	2 hr	-13
		End of Anaerobic	4 hr	-7
		End of Aerobic	6 hr	-8
		End of Settling	8 hr	-3
A3	0	End of Feeding	2 hr	-7
		End of Anaerobic	4 hr	-6
		End of Aerobic	6 hr	-8
		End of Settling	8 hr	-2
B1	50	End of Feeding	2 hr	25
		End of Anaerobic	4 hr	20
		End of Aerobic	6 hr	22
		End of Settling	8 hr	20
B2	50	End of Feeding	2 hr	40
		End of Anaerobic	4 hr	8
		End of Aerobic	6 hr	6
		End of Settling	8 hr	27
B3	50	End of Feeding	2 hr	37
		End of Anaerobic	4 hr	31
		End of Aerobic	6 hr	28
		End of Settling	8 hr	28

Seed,mL	DO dep
3	1.5
3	0.9
6	3.2
6	2.3
0	0



Appendix VI

Inhibition Test Results at 60 ppm

Date of Test: 3-25-97

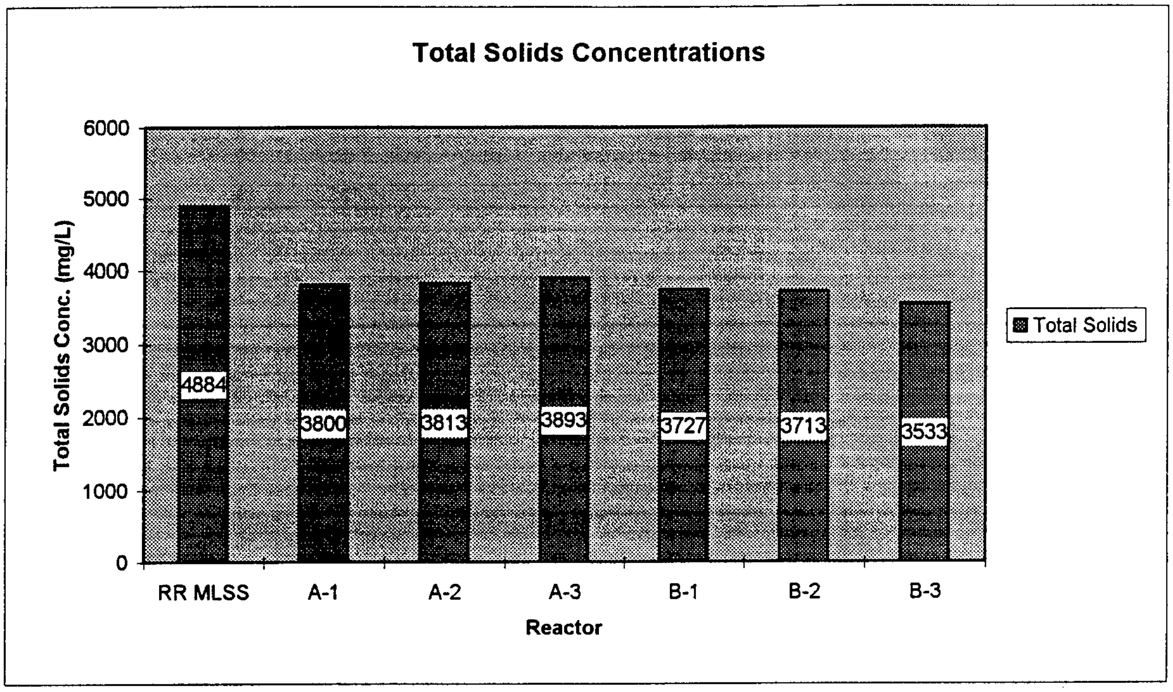
AFFF Conc. = 60 ppm

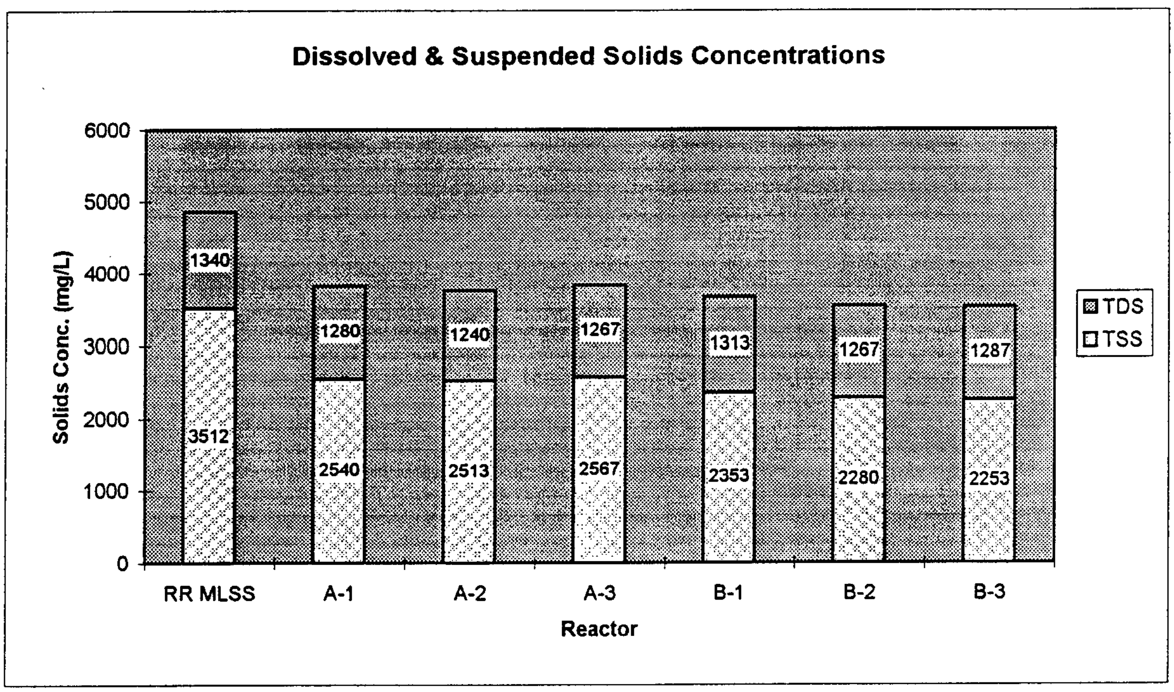
Solids Concentrations

		RR MLSS	A-1	A-2	A-3	B-1	B-2	B-3
			0 ppm AFFF	0 ppm AFFF	0 ppm AFFF	60 ppm AFFF	60 ppm AFFF	60 ppm AFFF
TSS	Empty wt. (gm)	1.0963	1.0973	1.1110	1.1061	1.1146	1.1101	1.1231
	wt.after heat (gm)	1.1841	1.1354	1.1487	1.1446	1.1499	1.1443	1.1569
	SampleVol. (mL)	25	15	15	15	15	15	15
	TSS mg/l	3512	2540	2513	2567	2353	2280	2253
TVS	Initial Weight	1.1841	1.1354	1.1487	1.1446	1.1499	1.1443	1.1569
	wt after 550oC	1.1045	1.0996	1.1135	1.1084	1.1168	1.1125	1.1251
	SampleVol. (mL)	25	15	15	15	15	15	15
	TVS mg/l	3184	2387	2347	2413	2207	2120	2120
TDS	Empty wt. (gm)	1.0234	1.0179	1.0103	1.0181	1.0271	1.0278	1.0289
	wt.after heat (gm)	1.0569	1.0371	1.0289	1.0371	1.0468	1.0468	1.0482
	SampleVol. (mL)	25	15	15	15	15	15	15
	TDS mg/l	1340	1280	1240	1267	1313	1267	1287
TS	Empty wt. (gm)	1.0296	1.0221	1.0112	1.0257	1.0254	1.0187	1.0260
	wt.after heat (gm)	1.1517	1.0791	1.0684	1.0841	1.0813	1.0744	1.0790
	SampleVol. (mL)	25	15	15	15	15	15	15
	TS mg/l	4884	3800	3813	3893	3727	3713	3533
Σ(TSS+TDS)	TS mg/l	4852	3820	3753	3833	3667	3547	3540

Date of Test: 3-25-97

AFFF Conc. = 60 ppm





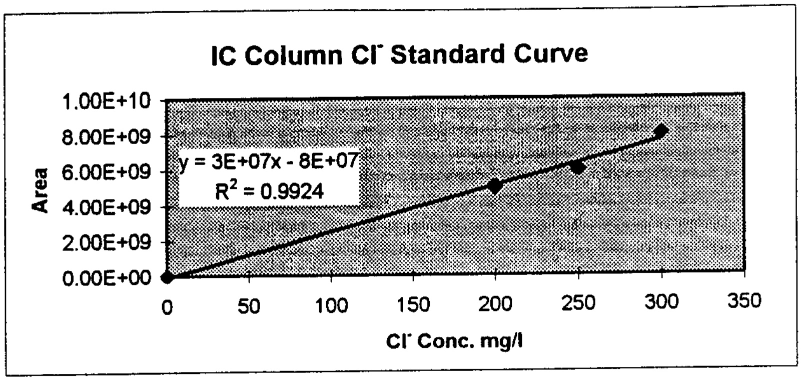
Date of Test: 3-25-97 Standards & Data AFFF Conc. = 60 ppm

Reactor	AFFF (ppm)	Stage	Time	NH3-N (mg/L)	TKN (mg/L)	PH	Alkalinity
		Feedstock		30.3	454.5	6.8	381.0
		RR Decant		0.3	6.4	7.5	161.5
A1	0	End of Feeding	2 hr	8.2	32.2	7.1	226.0
		End of Anaerobic	4 hr	10.0	28.6	7.3	274.5
		End of Aerobic	6 hr	0.1	34.6	7.5	210.0
		End of Settling	8 hr	0.2	36.2	7.5	148.5
A2	0	End of Feeding	2 hr	7.8	23.6	7.3	226.0
		End of Anaerobic	4 hr	8.9	26.5	7.3	274.5
		End of Aerobic	6 hr	0.1	31.0	7.4	164.5
		End of Settling	8 hr	0.1	36.2	7.6	142.0
A3	0	End of Feeding	2 hr	6.9	26.5	7.3	213.0
		End of Anaerobic	4 hr	8.2	26.5	7.2	242.0
		End of Aerobic	6 hr	0.1	21.0	7.4	155.5
		End of Settling	8 hr	0.2	39.1	7.6	148.5
B1	60	End of Feeding	2 hr	10.0	13.7	7.3	213.0
		End of Anaerobic	4 hr	11.3	12.2	7.3	239.0
		End of Aerobic	6 hr	0.3	17.3	7.4	187.0
		End of Settling	8 hr	0.3	18.0	7.6	129.0
B2	60	End of Feeding	2 hr	10.4	12.7	7.3	214.5
		End of Anaerobic	4 hr	10.9	21.8	7.4	200.0
		End of Aerobic	6 hr	0.3	21.8	7.5	174.5
		End of Settling	8 hr	0.2	16.6	7.6	129.0
B3	60	End of Feeding	2 hr	8.5	11.7	7.3	252.0
		End of Anaerobic	4 hr	9.6	23.6	7.4	242.0
		End of Aerobic	6 hr	0.4	27.6	7.4	168.0
		End of Settling	8 hr	0.2	29.8	7.5	135.5

Date of Test: 3-25-97 | Standards & Data | AFFF Conc. = 60 ppm

Reactor	AFFF (ppm)	Stage	Time	Cl- Area	Cl- (mg/L)	NO_2^--N Area	NO_2^--N (mg/L)	NO_3^--N Area	NO_3^--N (mg/L)	PO_4^--P Area	PO_4^--P (mg/L)
		Feedstock		7.00E+09	267.1	0	0.0	3.00E+06	0.9	5.00E+08	24.2
		RR Decant		8.00E+09	312.0	0	0.0	5.00E+09	103.5	5.00E+08	28.8
A1	0	End of Feeding	2 hr	7.00E+09	291.5	7.71E+08	14.5	4.00E+09	70.9	6.00E+08	30.8
		End of Anaerobic	4 hr	7.00E+09	286.5	9.16E+08	17.4	3.00E+09	60.3	6.00E+08	30.5
		End of Aerobic	6 hr	7.00E+09	289.5	4.87E+08	8.8	4.00E+09	89.7	6.00E+08	31.7
		End of Settling	8 hr	7.00E+09	294.4	4.15E+08	7.4	4.00E+09	87.8	6.00E+08	32.3
A2	0	End of Feeding	2 hr	7.00E+09	288.4	8.00E+08	15.1	3.00E+09	67.8	6.00E+08	30.5
		End of Anaerobic	4 hr	7.00E+09	288.3	9.19E+08	17.5	3.00E+09	59.7	6.00E+08	30.5
		End of Aerobic	6 hr	7.00E+09	288.5	3.99E+08	7.1	4.00E+09	90.4	6.00E+08	31.5
		End of Settling	8 hr	7.00E+09	290.9	3.51E+08	6.1	4.00E+09	87.7	6.00E+08	31.9
A3	0	End of Feeding	2 hr	7.00E+09	286.6	7.84E+08	14.8	3.00E+09	68.6	6.00E+08	30.0
		End of Anaerobic	4 hr	7.00E+09	289.1	8.94E+08	17.0	3.00E+09	62.5	6.00E+08	30.7
		End of Aerobic	6 hr	7.00E+09	287.4	3.88E+08	6.9	4.00E+09	90.6	6.00E+08	31.5
		End of Settling	8 hr	7.00E+09	292.2	3.43E+08	5.9	4.00E+09	89.7	6.00E+08	32.0
B1	60	End of Feeding	2 hr	7.00E+09	289.2	8.99E+08	17.1	3.00E+09	60.8	6.00E+08	30.7
		End of Anaerobic	4 hr	7.00E+09	287.3	8.87E+08	16.8	3.00E+09	55.2	6.00E+08	30.3
		End of Aerobic	6 hr	7.00E+09	288.1	4.95E+08	9.0	4.00E+09	83.1	6.00E+08	30.7
		End of Settling	8 hr	7.00E+09	291.6	5.17E+08	9.4	4.00E+09	84.5	6.00E+08	31.3
B2	60	End of Feeding	2 hr	7.00E+09	288.8	9.43E+08	17.9	3.00E+09	58.0	6.00E+08	30.9
		End of Anaerobic	4 hr	7.00E+09	287.3	9.33E+08	17.8	3.00E+09	53.4	6.00E+08	30.6
		End of Aerobic	6 hr	7.00E+09	289.9	6.11E+08	11.3	4.00E+09	81.5	6.00E+08	31.1
		End of Settling	8 hr	7.00E+09	290.1	6.02E+08	11.1	4.00E+09	82.5	6.00E+08	31.3
B3	60	End of Feeding	2 hr	7.00E+09	283.7	8.97E+08	17.0	3.00E+09	61.0	6.00E+08	30.0
		End of Anaerobic	4 hr	7.00E+09	286.0	9.29E+08	17.7	3.00E+09	55.5	6.00E+08	30.2
		End of Aerobic	6 hr	7.00E+09	288.3	5.80E+08	10.7	4.00E+09	82.5	6.00E+08	30.8
		End of Settling	8 hr	7.00E+09	293	5.57E+08	10.2	4.00E+09	86.3	6.00E+08	31.4
		Stand 2		5.00E+09	201.8	5.15E+08	11.9	5.00E+08	10.0	2.00E+08	9.6
		Stand 3		6.00E+09	251.2	1.00E+09	24.0	1.00E+09	20.0	3.00E+08	18.6
		Stand 4		8.00E+09	305.2	1.81E+09	44.3	2.00E+09	40.0	8.00E+08	42.3
		DI Water		0	2.7	0	0.0	0	0.0	0	0.0
		Standards used									
		STD 1		0	0	0	0	0	0	0	0
		STD 2		5.00E+09	200	5.12E+08	10	5.00E+08	10	2.00E+08	10
		STD 3		6.00E+09	250	1.00E+09	20	1.00E+09	20	4.00E+08	20
		STD 4		8.00E+09	300	1.80E+09	40	2.00E+09	40	8.00E+08	40

Date of Test: 3-25-97 | Standards & Data | AFFF Conc. = 60 ppm



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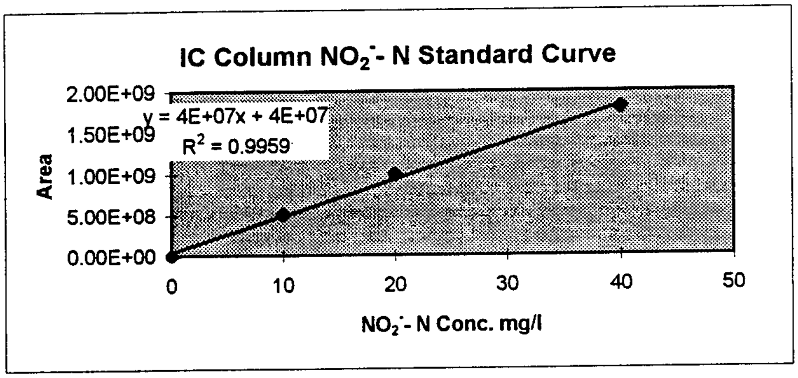

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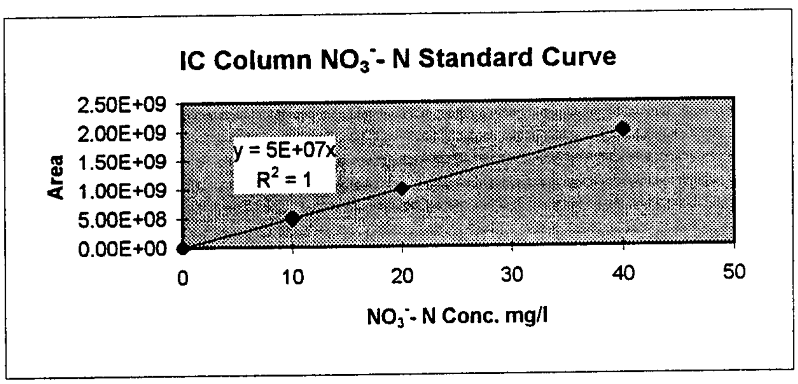

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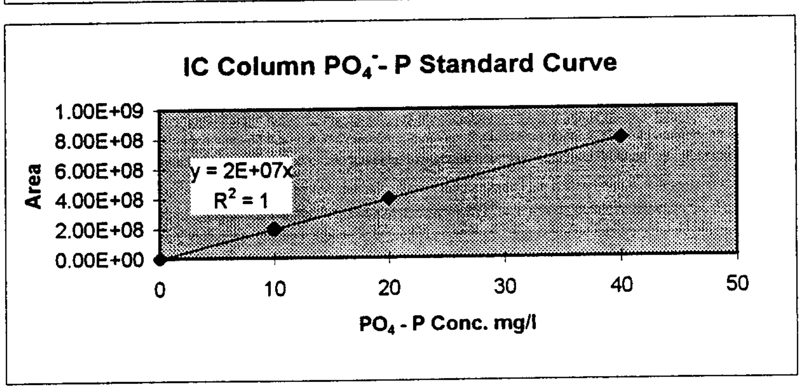
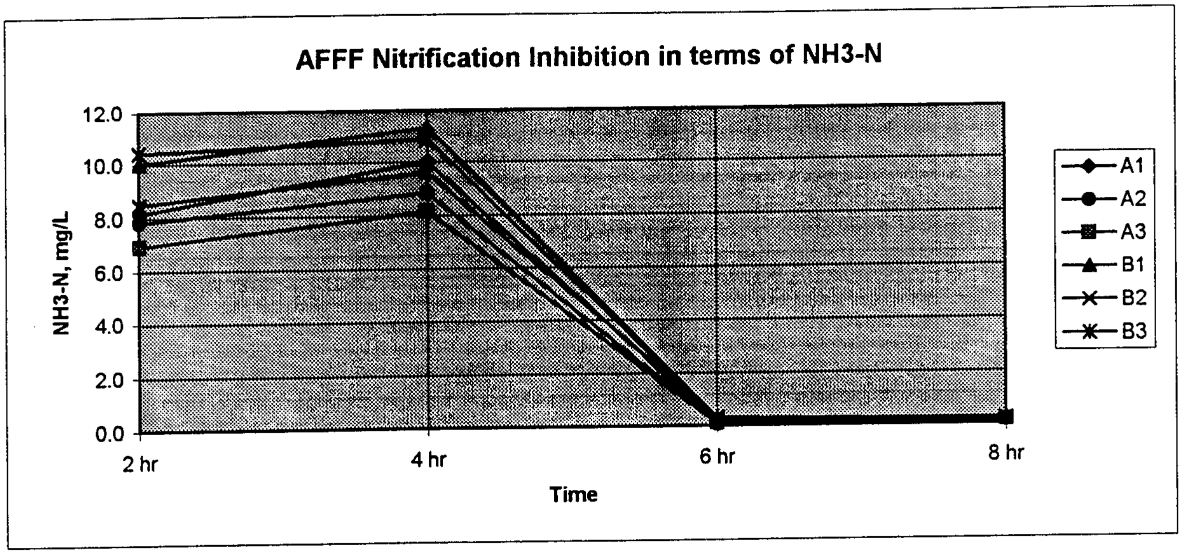


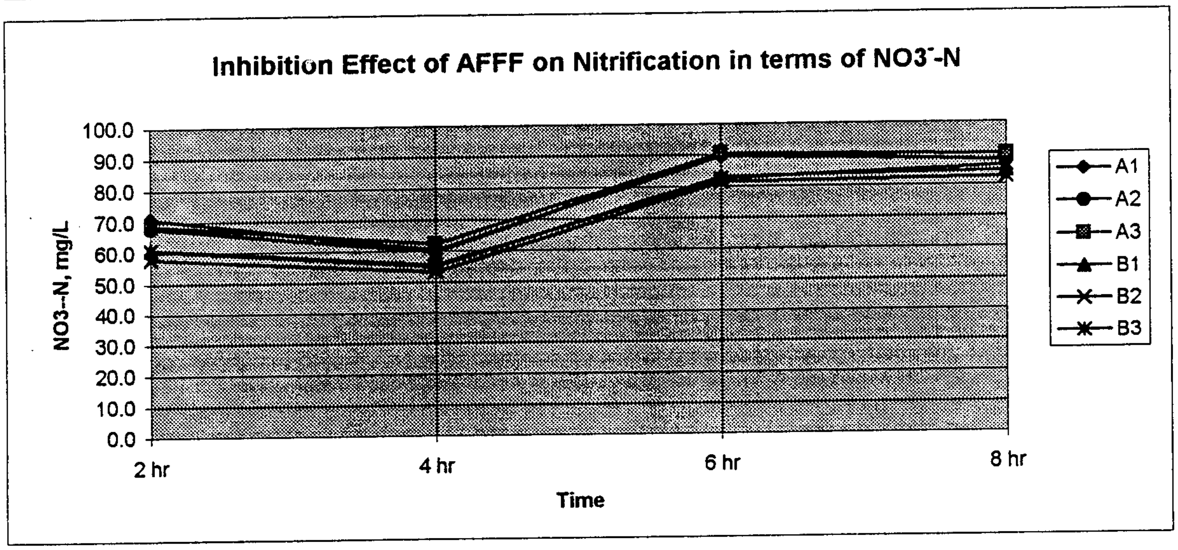
m = *2.00E+07*
i = *0.00E+00*

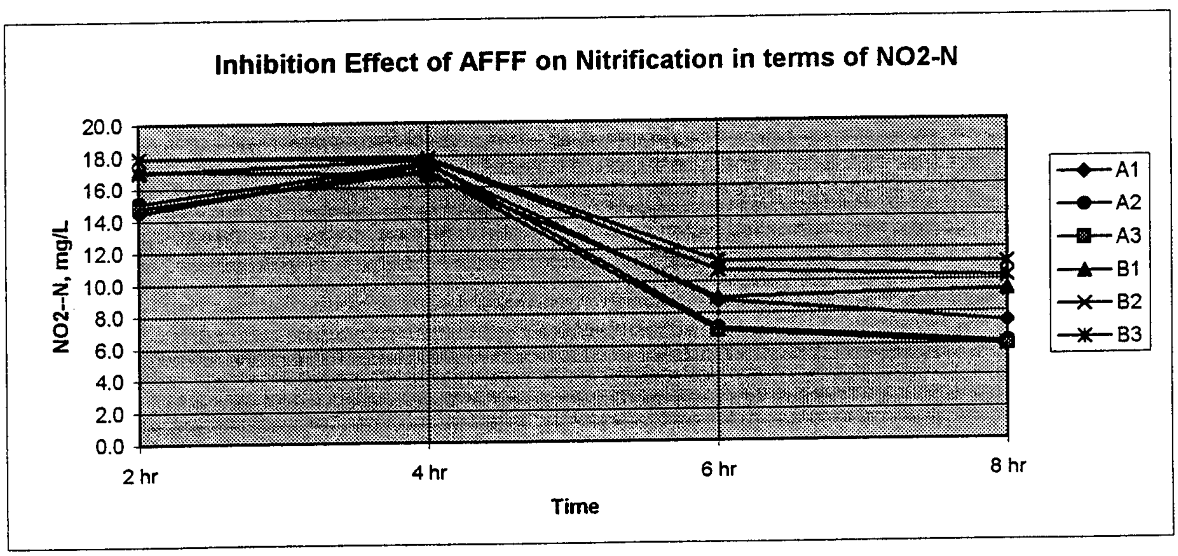
Date of Test: 3-25-97 Concentrations Table AFFF Conc. = 60 ppm

Reactor	AFFF (ppm)	Stage	Time	TKN	NH3-N	Org. N	NO2–N	NO3–N	Total N	Cl-	PO4-P
				Concentration, mg/L							
		Feedstock		454.5	30.3	424.3	0.0	0.9	455.4	267.1	24.2
		RR Decant		6.4	0.3	6.1	0.0	103.5	109.9	312.0	28.8
A1	0	End of Feeding	2 hr	32.2	8.2	24.0	14.5	70.9	117.6	291.5	30.8
		End of Anaerobic	4 hr	28.6	10.0	18.6	17.4	60.3	106.3	286.5	30.5
		End of Aerobic	6 hr	34.6	0.1	34.5	8.8	89.7	133.1	289.5	31.7
		End of Settling	8 hr	36.2	0.2	36.0	7.4	87.8	131.4	294.4	32.3
A2	0	End of Feeding	2 hr	23.6	7.8	15.8	15.1	67.8	106.5	288.4	30.5
		End of Anaerobic	4 hr	26.5	8.9	17.7	17.5	59.7	103.7	288.3	30.5
		End of Aerobic	6 hr	31.0	0.1	30.9	7.1	90.4	128.5	288.5	31.5
		End of Settling	8 hr	36.2	0.1	36.0	6.1	87.7	130.0	290.9	31.9
A3	0	End of Feeding	2 hr	26.5	6.9	19.6	14.8	68.6	109.9	286.6	30.0
		End of Anaerobic	4 hr	26.5	8.2	18.4	17.0	62.5	106.0	289.1	30.7
		End of Aerobic	6 hr	21.0	0.1	20.9	6.9	90.6	118.5	287.4	31.5
		End of Settling	8 hr	39.1	0.2	38.9	5.9	89.7	134.7	292.2	32.0
B1	60	End of Feeding	2 hr	13.7	10.0	3.7	17.1	60.8	91.6	289.2	30.7
		End of Anaerobic	4 hr	12.2	11.3	0.9	16.8	55.2	84.2	287.3	30.3
		End of Aerobic	6 hr	17.3	0.3	17.0	9.0	83.1	109.4	288.1	30.7
		End of Settling	8 hr	18.0	0.3	17.7	9.4	84.5	111.9	291.6	31.3
B2	60	End of Feeding	2 hr	12.7	10.4	2.2	17.9	58.0	88.6	288.8	30.9
		End of Anaerobic	4 hr	21.8	10.9	11.0	17.8	53.4	93.0	287.3	30.6
		End of Aerobic	6 hr	21.8	0.3	21.5	11.3	81.5	114.6	289.9	31.1
		End of Settling	8 hr	16.6	0.2	16.4	11.1	82.5	110.2	290.1	31.3
B3	60	End of Feeding	2 hr	11.7	8.5	3.2	17.0	61.0	89.7	283.7	30.0
		End of Anaerobic	4 hr	23.6	9.6	14.0	17.7	55.5	96.8	286.0	30.2
		End of Aerobic	6 hr	27.6	0.4	27.2	10.7	82.5	120.8	288.3	30.8
		End of Settling	8 hr	29.8	0.2	29.6	10.2	86.3	126.3	292.7	31.4

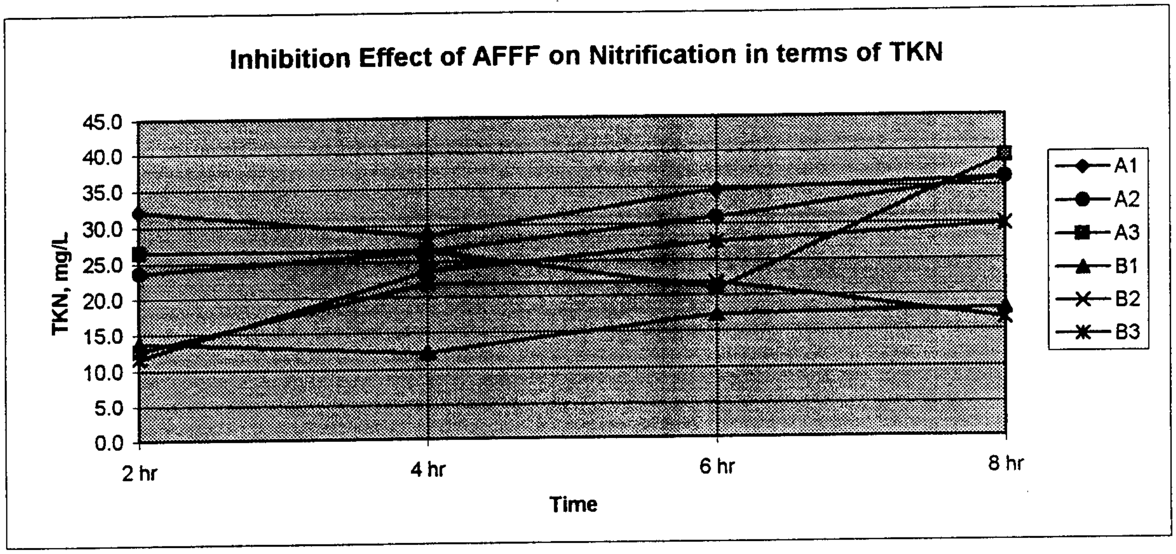
Date of Test: 3-25-97 NH3-N & TKN Charts AFFF Conc. = 60 ppm



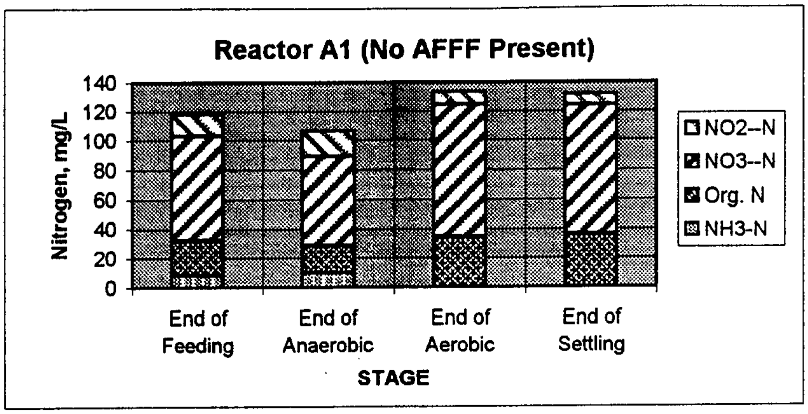


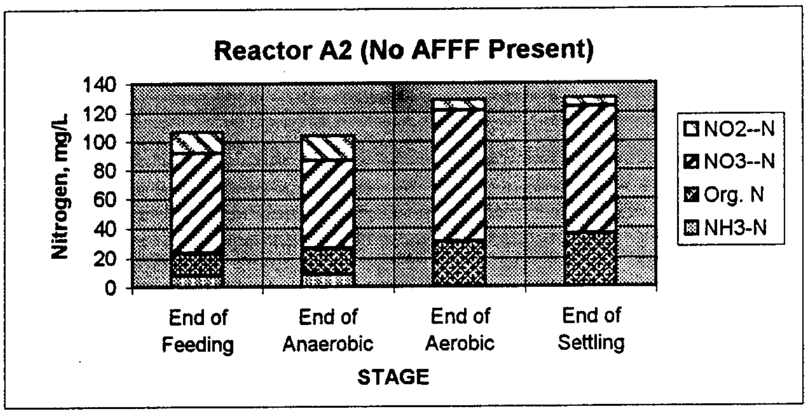


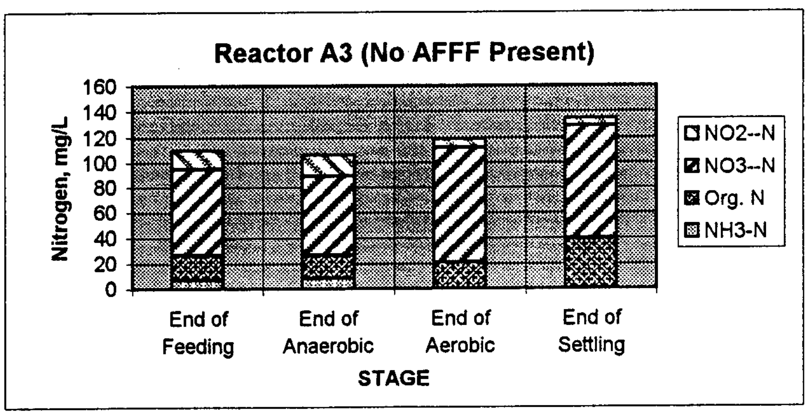
Date of Test: 3-25-97 NH3-N & TKN Charts AFFF Conc. = 60 ppm



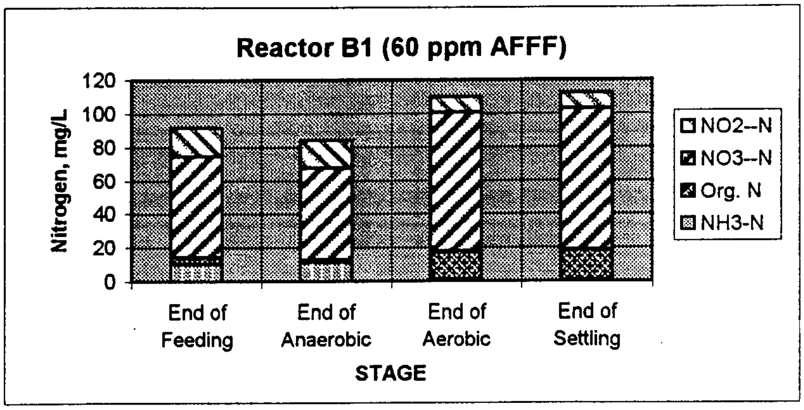
Date of Test: 3-25-97 Inhibition Reactors / Nitrogen Mass Balance AFFF Conc. = 60 ppm

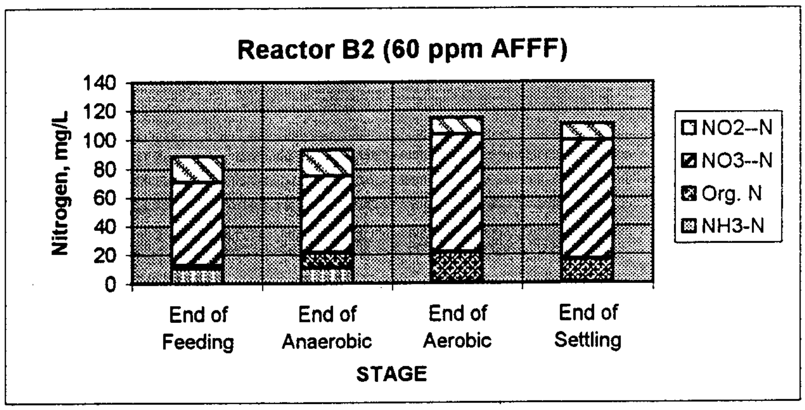


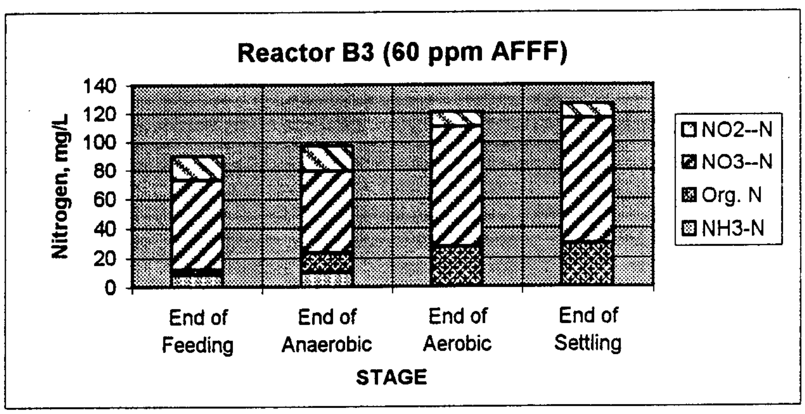




Date of Test: 3-25-97 Inhibition Reactors / Nitrogen Mass Balance AFFF Conc. = 60 ppm

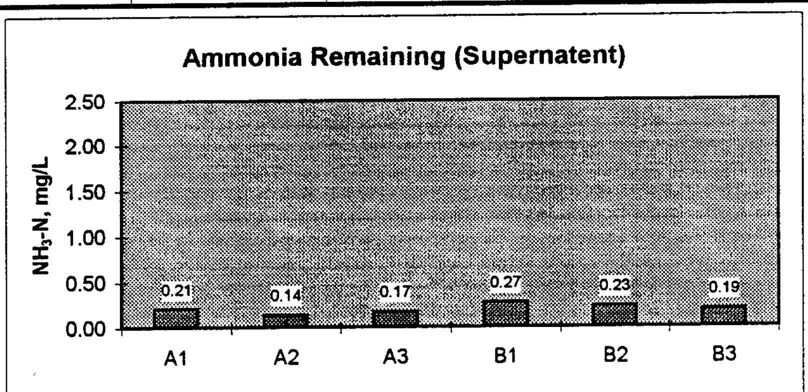


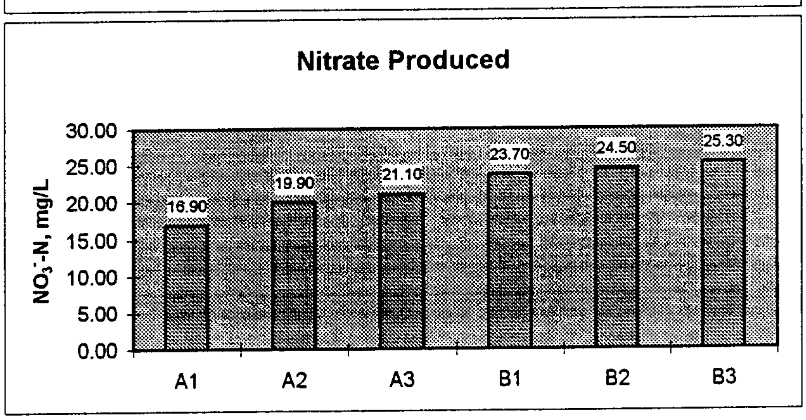




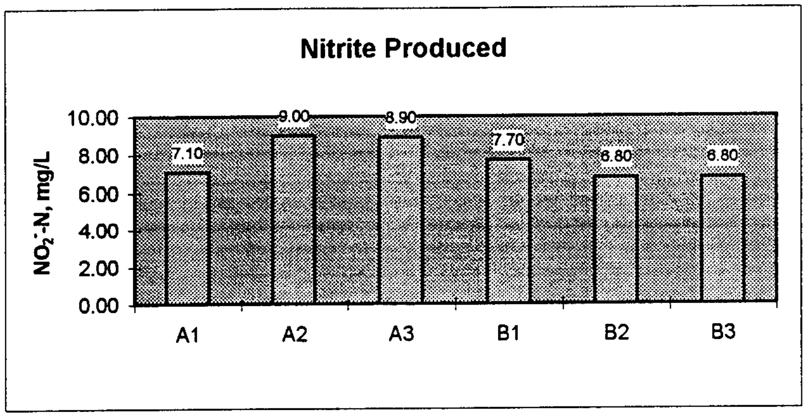
Date of Test: 3-25-97 Inhibition Reactors / NO3- & NO2 Produced AFFF Conc. = 60 ppm

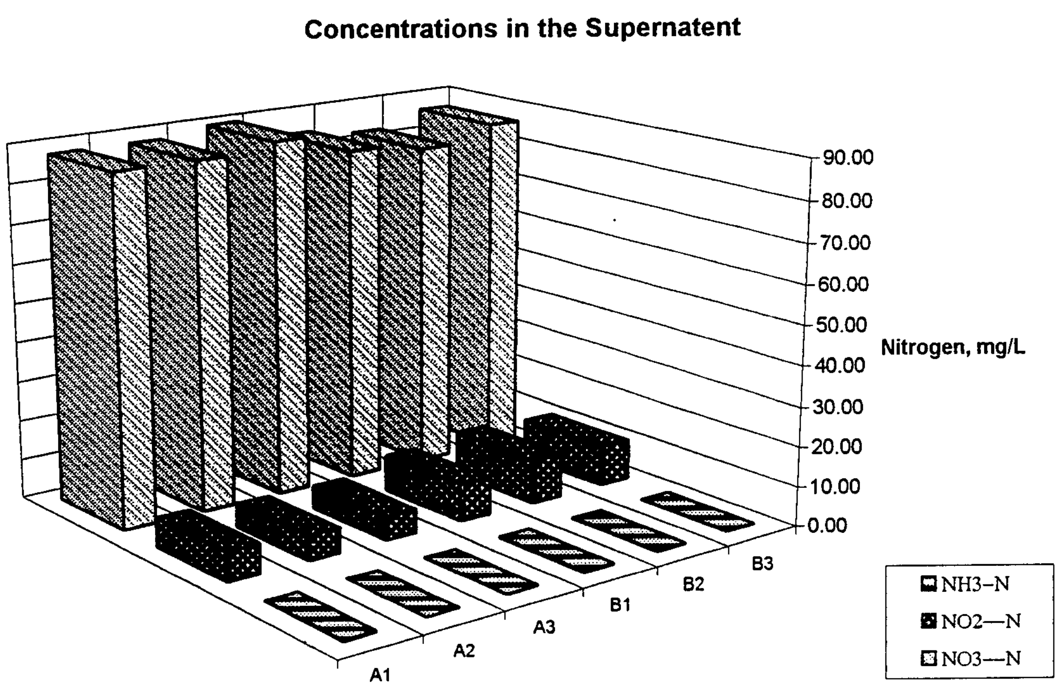
Reactor	AFFF ppm	Stage	Time	NH3-N	NO3--N	NO2--N	$\Delta(NO_3^-\text{-N})$	$\Delta(NO_2\text{-N})$
				Nitrogen Concentration, mg/L				
A1	0	End of Feeding	2 hr	8.15	70.9	14.5		
(Control)		End of Anaerobic	4 hr	10.01	60.3	17.4		
		End of Aerobic	6 hr	0.14	89.7	8.8		
		End of Settling	8 hr	0.21	87.8	7.4	16.90	7.10
A2	0	End of Feeding	2 hr	7.83	67.8	15.1		
(Control)		End of Anaerobic	4 hr	8.85	59.7	17.5		
		End of Aerobic	6 hr	0.07	90.4	7.1		
		End of Settling	8 hr	0.14	87.7	6.1	19.90	9.00
A3	0	End of Feeding	2 hr	6.92	68.6	14.8		
(Control)		End of Anaerobic	4 hr	8.15	62.5	17.0		
		End of Aerobic	6 hr	0.13	90.6	6.9		
		End of Settling	8 hr	0.17	89.7	5.9	21.10	8.90
B1	60	End of Feeding	2 hr	10.01	60.8	17.1		
		End of Anaerobic	4 hr	11.32	55.2	16.8		
		End of Aerobic	6 hr	0.32	83.1	9.0		
		End of Settling	8 hr	0.27	84.5	9.4	23.70	7.70
B2	60	End of Feeding	2 hr	10.43	58.0	17.9		
		End of Anaerobic	4 hr	10.86	53.4	17.8		
		End of Aerobic	6 hr	0.27	81.5	11.3		
		End of Settling	8 hr	0.23	82.5	11.1	24.50	6.80
B3	60	End of Feeding	2 hr	8.50	61.0	17.0		
		End of Anaerobic	4 hr	9.61	55.5	17.7		
		End of Aerobic	6 hr	0.35	82.5	10.7		
		End of Settling	8 hr	0.19	86.3	10.2	25.30	6.80





Date of Test: 3-25-97 Inhibition Reactors / NO3- & NO2 Produced AFFF Conc. = 60 ppm





Date of Test: 3-25-97 COD Concentration and % Removal AFFF Conc. = 60 ppm

Reactor	AFFF (ppm)	Stage	Time	COD ABS	COD (mg/L)	COD % COD Removal*
		Feedstock		0.371	**965.4**	
		RR Decant		0.014	**31.8**	
A1	0	End of Feeding	2 hr	0.018	**42.2**	87.7
		End of Anaerobic	4 hr	0.018	**42.2**	87.7
		End of Aerobic	6 hr	0.018	**42.2**	87.7
		End of Settling	8 hr	0.016	**37.0**	**89.2**
A2	0	End of Feeding	2 hr	0.027	**65.8**	80.8
		End of Anaerobic	4 hr	0.029	**71.0**	79.3
		End of Aerobic	6 hr	0.014	**31.8**	90.7
		End of Settling	8 hr	0.016	**37.0**	**89.2**
A3	0	End of Feeding	2 hr	0.023	**55.3**	83.9
		End of Anaerobic	4 hr	0.020	**47.5**	86.2
		End of Aerobic	6 hr	0.017	**39.6**	88.4
		End of Settling	8 hr	0.020	**47.5**	**86.2**
B1	60	End of Feeding	2 hr	0.155	**400.5**	66.8
		End of Anaerobic	4 hr	0.160	**413.6**	65.7
		End of Aerobic	6 hr	0.147	**379.6**	68.5
		End of Settling	8 hr	0.153	**395.3**	**67.2**
B2	60	End of Feeding	2 hr	0.155	**400.5**	66.8
		End of Anaerobic	4 hr	0.154	**397.9**	67.0
		End of Aerobic	6 hr	0.148	**382.2**	68.3
		End of Settling	8 hr	0.156	**403.1**	**66.6**
B3	60	End of Feeding	2 hr	0.153	**395.3**	67.2
		End of Anaerobic	4 hr	0.160	**413.6**	65.7
		End of Aerobic	6 hr	0.156	**403.1**	66.6
		End of Settling	8 hr	0.156	**403.1**	**66.6**
		STD 1		0.000	0	
		STD 2		0.100	250	
		STD 3		0.193	500	
		STD 4		0.289	750	
		STD 5		0.345	900	
		FS1 (Filtered)		0.366	952.3	
		FS2 (Filtered)		0.376	978.4	
		FS Average		**0.371**	**965.4**	
		RRSU1 (Filtered)		0.015	34.4	
		RRSU2 (Filtered)		0.013	29.2	
		RRSU Average		**0.014**	**31.8**	
		FS1 (Unfiltered)		0.374	973.2	
		FS2 (Unfiltered)				
		FS(Unfilt.) Average				
		RRSU1 (Unfiltered)				
		RRSU2 (Unfiltered)				
		RRSU(Unfilt)Average				

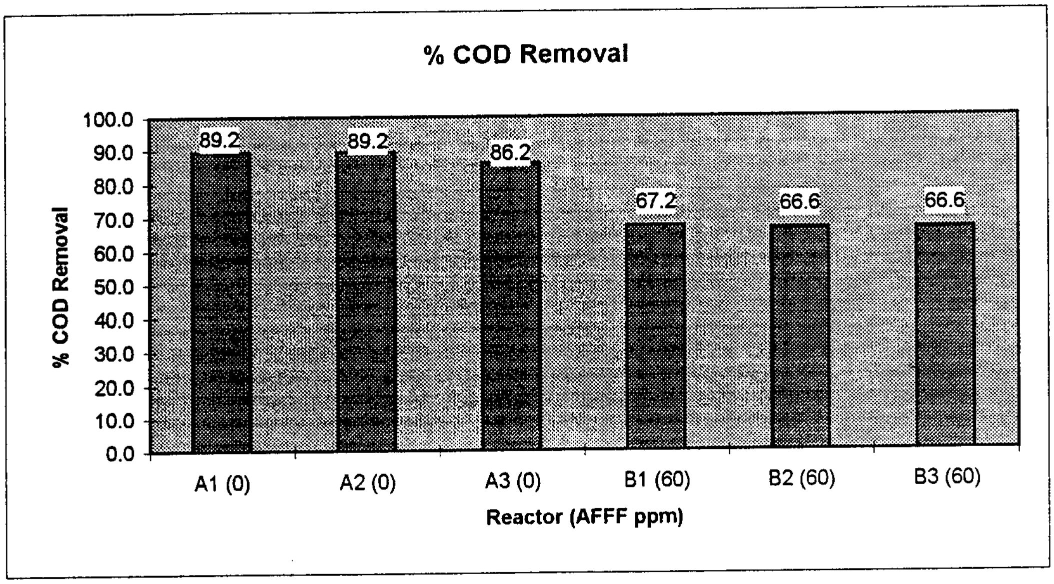
* The values of "COD % Removal" shown in table and chart above are accumulative figures based on the initial COD concentration at time 0 hr.

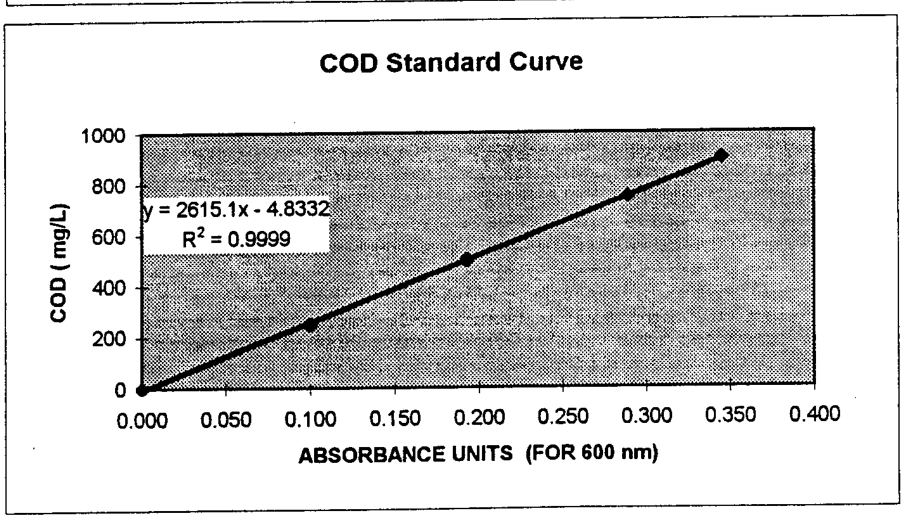
Date of Test: 3-25-97 | COD Concentration and % Removal | AFFF Conc. = 60 ppm

Initial COD at Time 0 hr.

Sample	Constituent	Vol (L)	COD mg/L	(AFFF+Feed) COD mg/l
Controls	RR Decant	4	31.8	127.1128
(A1,A2&A3)	Feedstock	2	965.4	1930.7378
	AFFF	0	0	0
	Total	6		**343.0**
Inhibition	RR Decant	4	31.8	127.1128
(B1,B2&B3)	Feedstock	2	965.4	1930.7378
	AFFF	2	2590	5180
	Total	6		**1206.3**

Reactor (AFFF ppm)	A1 (0)	A2 (0)	A3 (0)	B1 (60)	B2 (60)	B3 (60)
% COD Removal	89.2	89.2	86.2	67.2	66.6	66.6



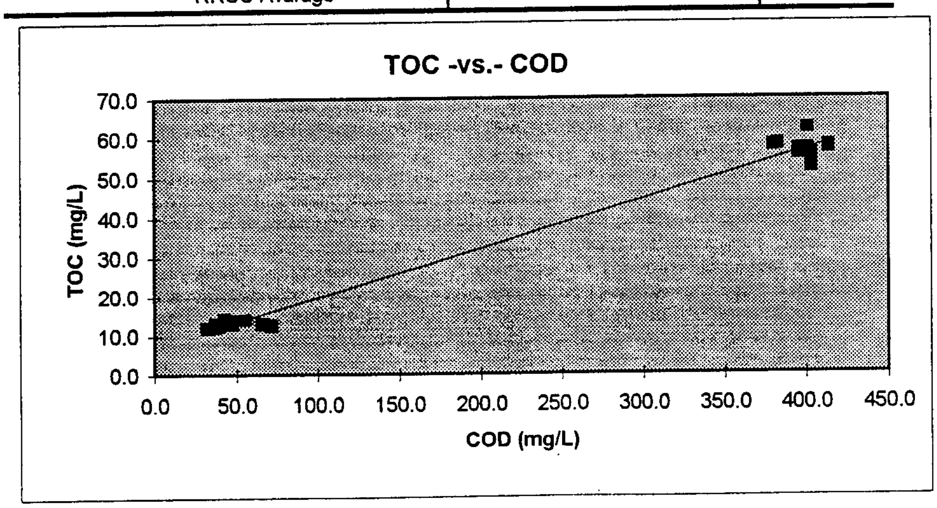


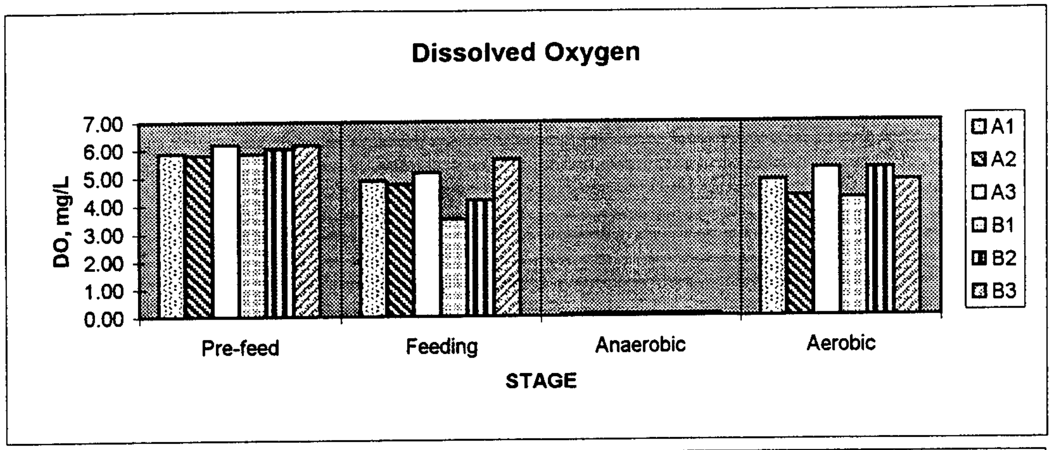
m = *2615.1*

i = *-4.8332*

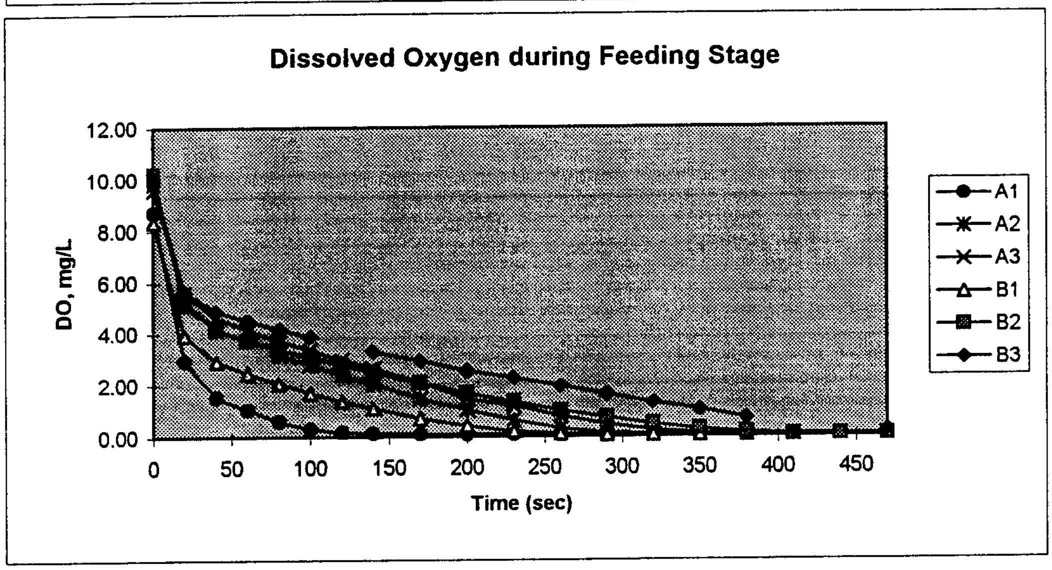
Date of Test: 3-25-97 | Concentrations Table | AFFF Conc. = 60 ppm

Reactor	AFFF (ppm)	Stage	Time	Concentration, mg/L BOD	COD	TOC	Alkalinity HCO3 (mg/l)
		Feedstock		**631.0**	965.4	391.2	381.0
		RR Decant		**1.1**	31.8	13.6	161.5
A1	0	End of Feeding	2 hr	**4.6**	42.2	**13.6**	226.0
		End of Anaerobic	4 hr	**3.7**	42.2	**13.9**	274.5
		End of Aerobic	6 hr	**2.4**	42.2	**14.4**	210.0
		End of Settling	8 hr	**2.7**	37.0	**13.3**	148.5
A2	0	End of Feeding	2 hr	**2.5**	65.8	**13.2**	226.0
		End of Anaerobic	4 hr	**1.9**	71.0	**12.6**	274.5
		End of Aerobic	6 hr	**1.9**	31.8	**11.9**	164.5
		End of Settling	8 hr	**1.1**	37.0	**12.2**	142.0
A3	0	End of Feeding	2 hr	**2.6**	55.3	**14.2**	213.0
		End of Anaerobic	4 hr	**2.0**	47.5	**13.9**	242.0
		End of Aerobic	6 hr	**1.0**	39.6	**12.6**	155.5
		End of Settling	8 hr	**1.2**	47.5	**13.0**	148.5
B1	60	End of Feeding	2 hr	**12.1**	400.5	**62.2**	213.0
		End of Anaerobic	4 hr	**11.4**	413.6	**57.2**	239.0
		End of Aerobic	6 hr	**10.7**	379.6	**57.9**	187.0
		End of Settling	8 hr	**10.2**	395.3	**56.8**	129.0
B2	60	End of Feeding	2 hr	**12.0**	400.5	**56.9**	214.5
		End of Anaerobic	4 hr	**11.4**	397.9	**56.9**	200.0
		End of Aerobic	6 hr	**10.8**	382.2	**58.1**	174.5
		End of Settling	8 hr	**9.7**	403.1	**55.6**	129.0
B3	60	End of Feeding	2 hr	**11.9**	395.3	**55.6**	252.0
		End of Anaerobic	4 hr	**11.3**	413.6	**57.6**	242.0
		End of Aerobic	6 hr	**11.0**	403.1	**55.4**	168.0
		End of Settling	8 hr	**10.0**	403.1	**52.4**	135.5
		FS1				392.5	
		FS2				389.4	
		FS3				391.8	
		FS Avarage				391.2	
		RRSU1				13.8	
		RRSU2				13.6	
		RRSU3				13.3	
		RRSU Avarage				13.57	

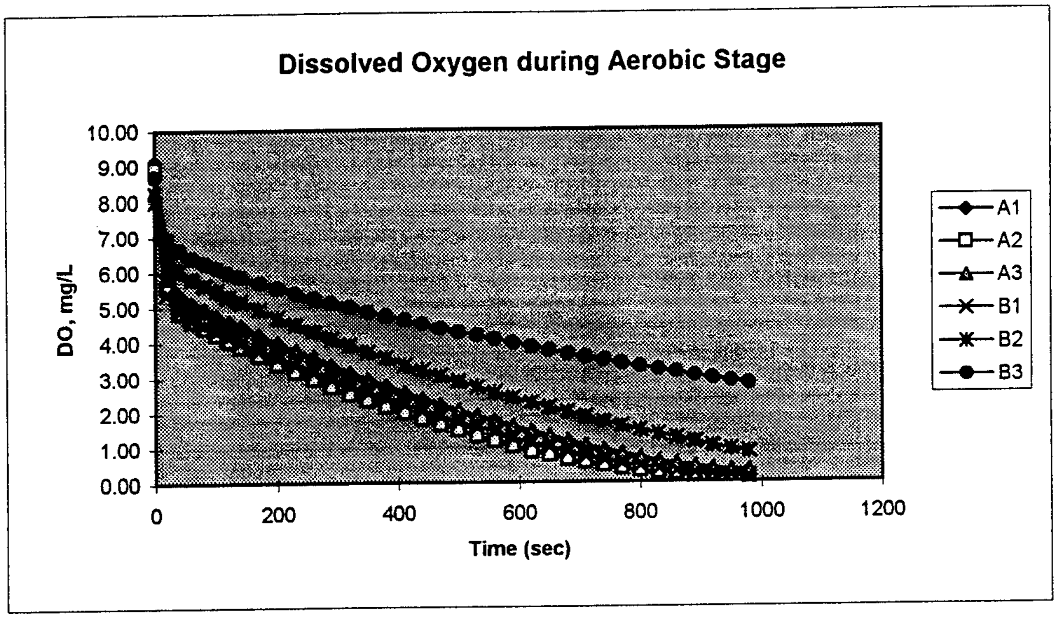




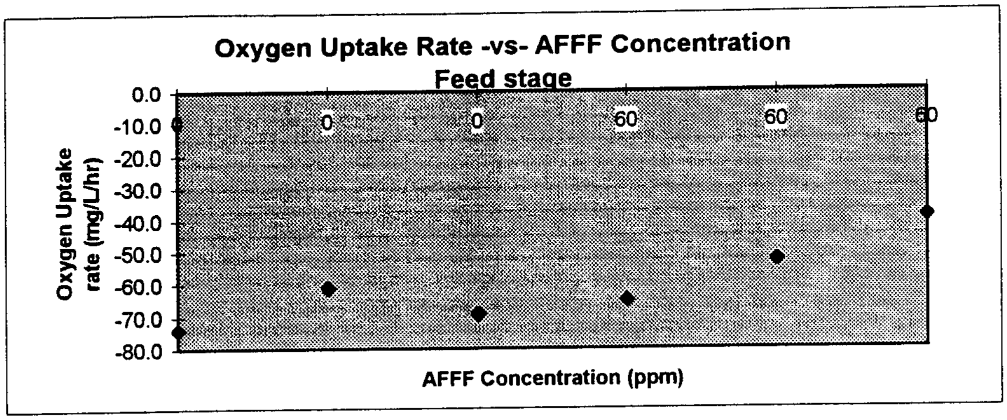
Dissolved Oxygen
DO, mg/L
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Pre-feed
Feeding
Anaerobic
Aerobic
STAGE
A1
A2
A3
B1
B2
B3



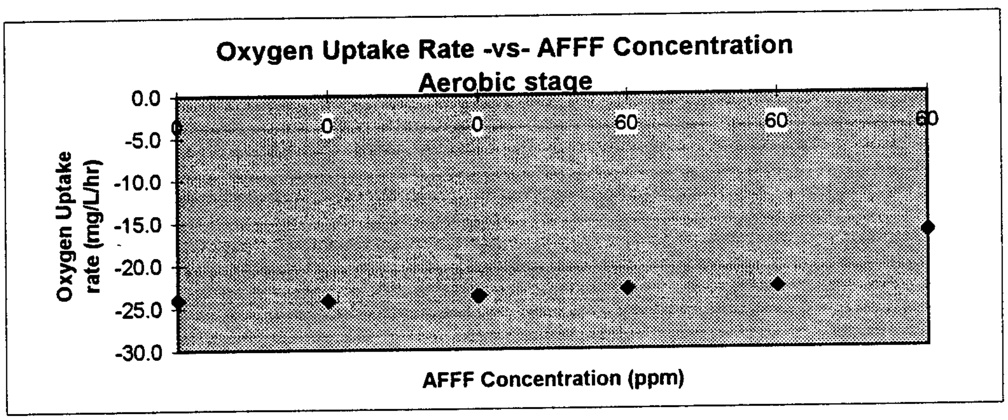
Dissolved Oxygen during Feeding Stage
DO, mg/L
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
50
100
150
200
250
300
350
400
450
Time (sec)
A1
A2
A3
B1
B2
B3



AFFF (ppm)	Samples	SOUR CALCULATION--Aerobic Stage Slope,mg/l/hr	Slope,mg/l/hr/MLVSS
0	A1	-24.0	-0.01007
0	A2	-24.2	-0.01031
0	A3	-23.7	-0.00983
60	B1	-23.0	-0.01042
60	B2	-22.8	-0.01076
60	B3	-16.4	-0.00772



AFFF		REGRESSION SUMMARY OUTPUT			
(ppm)	Samples	R Square	Intercept	Slope,mg/l/sec	Slope,mg/l/hr
0	A1	0.988	2.311	-0.021	-74.0
0	A2	0.996	4.461	-0.017	-61.3
0	A3	0.998	5.325	-0.019	-69.3
60	B1	0.994	3.561	-0.018	-65.1
60	B2	0.992	4.609	-0.015	-52.8
60	B3	0.998	4.798	-0.011	-39.4



AFFF		REGRESSION SUMMARY OUTPUT			
(ppm)	Samples	R Square	Intercept	Slope,mg/l/sec	Slope,mg/l/hr
0	A1	0.992	5.356	-0.007	-24.0
0	A2	0.989	4.836	-0.007	-24.2
0	A3	0.995	5.377	-0.007	-23.7
60	B1	0.994	4.926	-0.006	-23.0
60	B2	0.993	6.055	-0.006	-22.8
60	B3	0.985	6.540	-0.005	-16.4

AFFF PPM	Samples	SOUR CALCULATION--Feed Stage Slope,mg/l/hr	Slope,mg/l/hr/MLVSS
0	A1	-73.98	-0.03099
0	A2	-61.26	-0.0261
0	A3	-69.29	-0.02872
60	B1	-65.1	-0.0295
60	B2	-52.84	-0.02492
60	B3	-39.38	-0.01858

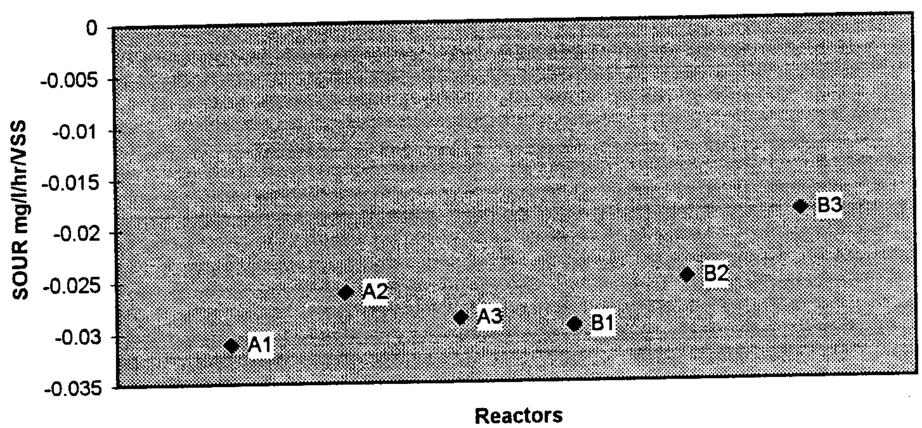


Figure 3-1: Specific Oxygen uptake rates (SOUR's) during the feed stage for 60 ppm AFFF (A--Control, B--Inhibition)

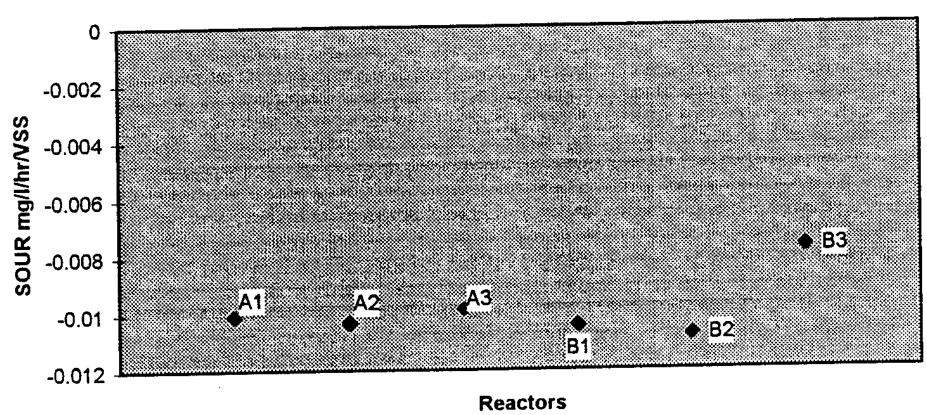


Figure 3-2: Specific Oxygen uptake rates (SOUR's) during the aerobic stage for 60 ppm AFFF (A--Control, B-Inhibition)

Date of Test: 3-25-97 | BOD$_5$ of Inhibition Run | AFFF Conc. = 60 ppm

Date, initial: 3/26/97 (Passed midnight) Date, final: 3/31/97

	Time 2 hr						
Bottle No.	111	70	40	28	75	23	Remarks
Sample Location	A1	A2	A3	B1	B2	B3	
% Sample in BOD Bottle	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	
Initial D.O. (mg/L)	8.28	8.31	8.28	8.10	8.04	8.04	
Final D.O. (mg/L)	4.03	5.10	5.04	0.09	0.09	0.12	Note 4
D.O. Depletion	4.25	3.21	3.24	8.01	7.95	7.92	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	2.0	2.0	2.0	2.0	2.0	2.0	
BOD of Sample	5	3	3	12	12	12	
Average BOD (mg/L)		3			12		

	Time 4 hr						
Bottle No.	109	555	230	68	171	888	Remarks
Sample Location	A1	A2	A3	B1	B2	B3	
% Sample in BOD Bottle	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	
Initial D.O. (mg/L)	7.93	7.96	7.95	7.73	7.74	7.73	
Final D.O. (mg/L)	4.13	5.06	5.01	0.09	0.09	0.12	Note 4
D.O. Depletion	3.80	2.90	2.94	7.64	7.65	7.61	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	2.0	2.0	2.0	2.0	2.0	2.0	
BOD of Sample	4	2	2	11	11	11	
Average BOD (mg/L)		3			11		

	Time 6 hr						
Bottle No.	114	48	10	103	116	19	Remarks
Sample Location	A1	A2	A3	B1	B2	B3	
% Sample in BOD Bottle	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	
Initial D.O. (mg/L)	7.64	7.65	7.61	7.38	7.44	7.52	
Final D.O. (mg/L)	4.48	4.73	5.18	0.08	0.08	0.08	Note 4
D.O. Depletion	3.16	2.92	2.43	7.30	7.36	7.44	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	2.0	2.0	2.0	2.0	2.0	2.0	
BOD of Sample	2	2	1	11	11	11	
Average BOD (mg/L)		2			11		

	Time 8 hr						
Bottle No.	268	999	108	187	666	53	Remarks
Sample Location	A1	A2	A3	B1	B2	B3	
% Sample in BOD Bottle	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	
Initial D.O. (mg/L)	6.62	6.78	6.74	7.12	6.91	7.06	
Final D.O. (mg/L)	3.32	4.26	4.17	0.09	0.13	0.13	Note 4
D.O. Depletion	3.30	2.52	2.57	7.03	6.78	6.93	Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
Seed Correction	2.0	2.0	2.0	2.0	2.0	2.0	
BOD of Sample	3	1	1	10	10	10	
Average BOD (mg/L)		2			10		

Date of Test: 3-25-97 BOD$_5$ of Inhibition Run AFFF Conc. = 60 ppm

Bottle No.	64	41	"Seed"	G/G #1	G/G #2	Blank	
Sample Location	Seed Control	Seed Control	Average	G/G Acid	G/G Acid	Blank	Remarks
% Sample in BOD Bottle	-	-	-	2.0%	2.0%	100.0%	
Initial D.O. (mg/L)	8.24	8.21	-	8.21	8.20	8.25	
Final D.O. (mg/L)	6.09	6.45	-	3.92	4.03	7.32	
D.O. Depletion	2.15	1.76	2.0	4.29	4.17	0.93	Notes 1 & 2
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%	-	Note 3
Seed Correction	-	-	-	2.0	2.0	-	Note 6
BOD of Sample (mg/L)	215	176	196	117	111	0.93	

Bottle No.	14	22	65	777	3		Remarks
Sample Location	Unfilt. FS	U/F FS&AFFF	Filtered FS	Filt. FS&AFFF	RRSU		
% Sample in BOD Bottle	0.5%	0.5%	0.5%	0.5%	50.0%		
Initial D.O. (mg/L)	8.23	8.20	8.21	8.35	8.31		
Final D.O. (mg/L)	3.08	0.08	3.10	0.09	5.80		Note 4
D.O. Depletion	5.15	8.12	5.11	8.26	2.51		Note 5
% Seed in BOD Bottle	1.0%	1.0%	1.0%	1.0%	1.0%		
Seed Correction	2.0	2.0	2.0	2.0	2.0		
BOD of Sample	639	1233	631	1261	1		

Notes:

1 As per Standard Methods, the Seed Control DO depletion must be between 0.6 and 1.0 mg/L
2. For the Blank, the DO depletion should not be greater than 0.2 mg/L, and preferably not greater than 0.1 mg/L
3. Seed was prepared with 100mL of filtered decant from ref. reactor (collected @ 10am), 100mL of Dilution water, and one Polyseed capsule.
4 The residual DO of samples should be equal or greater than 1 mg/L.
5. The DO depletion of samples should be equal or greater than 2 mg/L.
6. The BOD of Glucose/Glutamic acid should be between 198 + or - 30.5 mg/L.

Reactor	AFFF (ppm)	Stage	Time	BOD5
		Feedstock		631
		RR Decant		1
A1	0	End of Feeding	2 hr	5
		End of Anaerobic	4 hr	4
		End of Aerobic	6 hr	2
		End of Settling	8 hr	3
A2	0	End of Feeding	2 hr	3
		End of Anaerobic	4 hr	2
		End of Aerobic	6 hr	2
		End of Settling	8 hr	1
A3	0	End of Feeding	2 hr	3
		End of Anaerobic	4 hr	2
		End of Aerobic	6 hr	1
		End of Settling	8 hr	1
B1	50	End of Feeding	2 hr	12
		End of Anaerobic	4 hr	11
		End of Aerobic	6 hr	11
		End of Settling	8 hr	10
B2	50	End of Feeding	2 hr	12
		End of Anaerobic	4 hr	11
		End of Aerobic	6 hr	11
		End of Settling	8 hr	10
B3	50	End of Feeding	2 hr	12
		End of Anaerobic	4 hr	11
		End of Aerobic	6 hr	11
		End of Settling	8 hr	10